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[ 625 .162 (.494) & 656 .254 (.494) ]

# The new Swiss regulations relating to the gates and signalling of level crossings,[1]

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Figs. 1 to 5, pp. 2839 to 2845.

On 1 June 1929, new regulations came into force, promulgated by the Swiss Federal Council, relating to the « *gates and signalling of the level crossings of railways over public highways and roads* ». These regulations settle in a uniform manner, and for the whole extent of the country, the question of protecting level crossings.

At the present time, this question occupies the attention of the Authorities and Railway Administrations of different European countries, and possibly it will interest the readers of the *Bulletin* to have some information regarding the principles of these regulations.

The constant and definitely progressive increase in the number of accidents and possible accidents at railway level crossings of arterial roads induced the Railway Section of the Federal Post and Railway Department some years ago, to get into touch with the interested parties with a view to greater safety at level crossings. Early in 1924, a preliminary conference took place between the representatives of the Federal authorities and the automobile associations. It was then agreed that it was above all indispensable to give timely warning to the drivers of motor vehicles of the proximity of level crossings by means of triangular road signs carrying the conventional signs (a gate or a locomotive). These signs which belong to the system of road signs, and are approved by the International Motor Traffic Convention, were subseqnently set up at a large number of level crossings.

It very soon appeared, however, that these measures are not, in themselves, enough to guarantee safety. The use of motors increased considerably, and at the same time there was an increase in the number of the cases in which trains were endangered at level crossings. The enquiries showed that the major portion of these occurrences were due to imprudence or inattention on the part of the drivers of these road vehicles, or again to the fact that the drivers did not pay attention to the level crossings, or were

(1) Translated from the French.

too late in recognising them. The conclusion that the triangular road signs were not sufficient to attract the attention of road users forced itself upon all concerned, and as a consequence it was considered necessary to seek some means of better indicating the danger point, that is to say, the level crossing itself. The suggestions offered to this end were the object of numerous trials as to their effectiveness under the most widely different conditions which were carried out in agreement with the public authorities, the railway administrations, and the road users. The new Regulations of the Federal Council which form the subject of this paper, are the final result. Their main provisions will be cited and briefly commented upon, thus enabling, if the need arises, reference to be made to some of the work which led up to them.

Article 1.

*Scope.*

The provisions of the present Regulations shall apply to all level crossings of the Federal Railways and of other railways subject to Swiss legislation, with public highways and roads.

The Federal supervising authority in matters affecting the railways (hereinafter called « supervising authority ») shall decide in each case, after consulting the cantonal government, if the present Regulations are applicable to the level crossings of highways and roads by tramways or road railways.

The whole the Swiss railway system measures 5 918 km. (3 677 miles), distributed as follows :

| | | |
|---|---|---|
| 1. Federal Railways | 2 882 km. | (1 790.8 miles). |
| 2. Private standard gauge railways. | 780 — | ( 484.6 — ). |
| 3. Foreign railways in Swiss territory | 46 — | ( 28.6 — ). |
| 4. Private narrow gauge railways. | 1 661 — | (1 032.0 — ). |
| 5. Private rack railways | 109 — | ( 67.7 — ). |
| 6. Town tramways | 388 — | ( 241.0 — ). |
| 7. Private funicular railways | 52 — | ( 32.3 — ). |

Independent of the 3 200 road crossings above or below the track, the lines mentioned under figures 1 to 4 count at the present time in round numbers 9 100 level crossings, 5 500 of which are public and 3 600 private. In view of the fact that the scope of the Regulations includes all level crossings of the Federal Railways and of the other Companies subject to Swiss legislation, with public highways and roads, that is to say, therefore, to all lines or sections of lines in Swiss territory, it follows that the 5 500 public level crossings must all be equipped with signals in agreement with the new Regulations.

Article 2.

*Type of railway protection at level crossings.*

By protection of the railway, in the meaning of the law, is understood :

1. *Gates,* operated by railway employees or actuated automatically by the train.

2. *Optical and acoustical signals* by means of signals actuated by railway employees or automatically by the train.

3. *Simple indicator,* by means of *warning signals,* at unguarded level crossings, where road users themselves should before crossing, make certain that no train is approaching.

The legal provisions in force up to the present in Switzerland only recognised

as the protection of a level crossing, the actual closing of the crossing by means of gates. There still existed, principally on secondary lines, numerous unguarded level crossings provided merely with a warning notice on which appeared the words « Beware of the train » or « Danger. Unguarded level crossing ». The types of railway protection specified in sections 1 and 3 of this article 2 (gates and simple indicator) thus originate from the method formerly adopted, with the sole difference that, in the latter case, the danger notice is replaced by a uniform warning signal. The optical and acoustical mode of signalling laid down in section 2 constitutes, on the other hand, an innovation, that is to say, the idea of the « signalled » closing of a crossing in place of an « actual » closing.

ARTICLE 3.

1. Level crossings coming within the scope of the Regulations shall be indicated uniformly by *level crossing signals* (hereinafter called « principal signals ») placed facing the road.

The cost of installing and maintaining these principal signals shall be at the expense of the railway.

2. The installation and maintenance of *advanced signals* (1) intended for the

(1) A plate in the shape of an equilateral triangle with sides 1 metre (3 ft. 3 3/8 in.) long, with a red border and white background on which shall be represented, in black, the type of railway protection at the level crossing in question, namely :

A gate : guarded level crossing, protected by gates in accordance with Article 2, Section 1, or by optical and acoustical signals, in agreement with Article 2, Section 2;

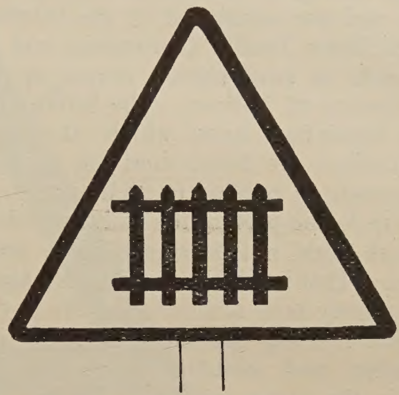
A conventional locomotive : unguarded level crossing, with a simple warning signal, in accordance with Article 2, Section 3 (Appendix 1).

**Appendix 1**

**Advanced signal.**

ARTICLE 3[2]

**For guarded level-crossings**



**For unguarded level-crossings.**

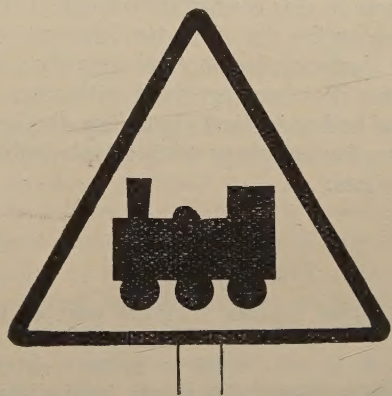


Fig. 1.

road traffic in agreement with Article 9 of the International Convention of 24 April 1926 relating to road traffic shall be, as in the past, left to the care of the road supervising authorities.

Obviously the installation and maintenance of the level-crossing signals called « principal signals », which are to be placed at the crossing itself and on

ground appertaining to it, fall upon the railway, because they form an important part of its equipment.

The contrary applies to the triangular signals called « advanced signals ». These belong to the system of road signals, and are mentioned in the International Motor Traffic Convention, and in the code of road signals drawn up by the League of Nations. The Swiss railway legislation, upon which the new Regulations are based does not contain any provision relating to such signals, so that up to the present the railway undertakings could not be compelled to erect them. That is why these advanced signs have merely been mentioned in the Regulations, it being specified that their installation and maintenance should be, « as in the past », left to the care of the supervising authorities of the roads. A footnote in this connexion contains information on the use of the two international signs (gate or locomotive) namely : the gate for crossings provided with gates or optical and acoustical signalling, the locomotive for crossings with simple indication signs.

### Article 4.

### *Principal signals.*

*Principal signals,* forming part of the railway equipment, shall be placed on roads frequently used by motor vehicles on either side of the track, immediately before the level-crossing, if possible on ground belonging to the railway, and facing the road, namely :

a) *In the case of barriers :*

1. A plate in the form of an equilateral triangle of 70 cm. (2 ft. 3 1/2 in.) side, with a black border 7 cm. (2 3/4 inches) wide and a white background, fixed to the barrier and in the middle of the road, or in the most conspicuous position from the direction of approach.

2. According to the particular condition of the site, there shall be fixed to the triangular plate either 15 red reflectors in the black border, or a red light on the white background, shielded from the track (Appendix 2).

b) *In the case of optical and acoustical signalling :*

1. In place of the gates, there shall be uniformly erected intermittent light signals, in triangular form with three red intermittent lights and a warning bell or siren (Appendix 3);

2. The winking of the lights, or the warning by bell or siren shall begin 30 to 45 seconds before the train passes, and shall cease when the end of the train has passed the crossing.

3. The lights shall make about 80 flashes per minute.

4. As a general rule, the red light should be shielded from the train.

5. As a general rule, it should be possible for train employees to check the working of the signals by means of yellow lights placed at the side of the signals themselves, or by pilot lamps placed in suitable positions along the track. In the absence of these arrangements, or in special circumstances, electrical apparatus for controlling the current of the circuit of winking lights should be provided either at the next station or at the nearest signal box.

6. As a general rule, a winking light signal shall be placed on eiher side of the track, if possible on the right of the road when facing the railway.

7. Each installation of winking light signals shall be approved by the supervising authority, in agreement with the cantonal government.

8. In special cases, the supervising authority may also require the installation of winking light signals at level crossings at present unguarded.

c) *When there is simple indication by means of warning signals :*

1. The large cross-shaped signal shall

**Appendix 2.**

**Triangular plate for gates.**

Type with reflectors.

ARTICLE 4a.

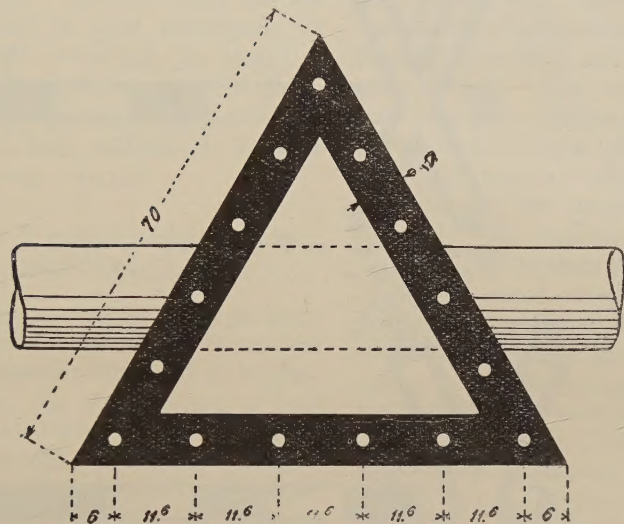



Fig. 2.

be used uniformly, with a red border 6 cm. (2 3/8 inches) wide, on a white background, the arms of the cross to be 1 metre (3 ft. 3 3/8 in.) long by 25 cm. (9 7/8 inches) wide and to form angles of 50 and 130° (Appendix 4).

2. One of these cross-shaped signals shall be placed on either side of the track, if possible on the right of the road when facing the railway.

Exceptions to these provisions shall be subject in each case to the approval of the supervising authority.

This article contains the provisions applicable in the case of *roads frequently used by motor vehicles*, that is to say, therefore, principally to crossings with main roads. It is thus necessary to distinguish, according to Article 2, between :

a) *The case of gates.*

The shape and dimensions of the triangular gate plates were fixed after long and numerous tests carried out on both the Federal and private railways. The need for a better method of warning had made itself particularly felt at night, seeing that the number of closed gate barriers run into by motors was continually increasing.

There could be no question, if only from the point of view of expense, of making it compulsory for all barriers to be fitted with red lights. It was necessary therefore to confine oneself to a device fulfilling the same object but entailing the minimum first cost and upkeep expenses. The reflectors called « cataphotes » gave the best results. They are illuminated by the motor headlights and indicate the obstacle in a perfectly satisfactory manner to the drivers of the motors, while possessing a sufficient angle of dispersion. A large number of barriers on the Federal railways and on private railways have already been fitted with these triangular plates provided with

**Appendix 3.**

## Winking light signal.

ARTICLE 4*b*.

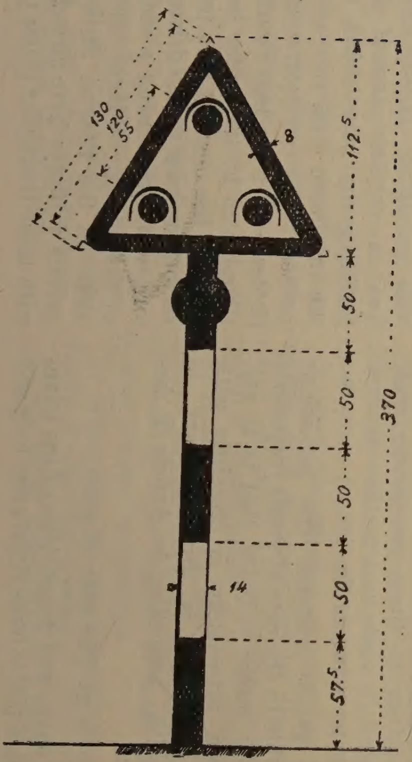



Fig. 3.

**Appendix 4.**

## Warning signal for unguarded level-crossings.

ARTICLE 4*c*.

ARTICLE 5*c*.

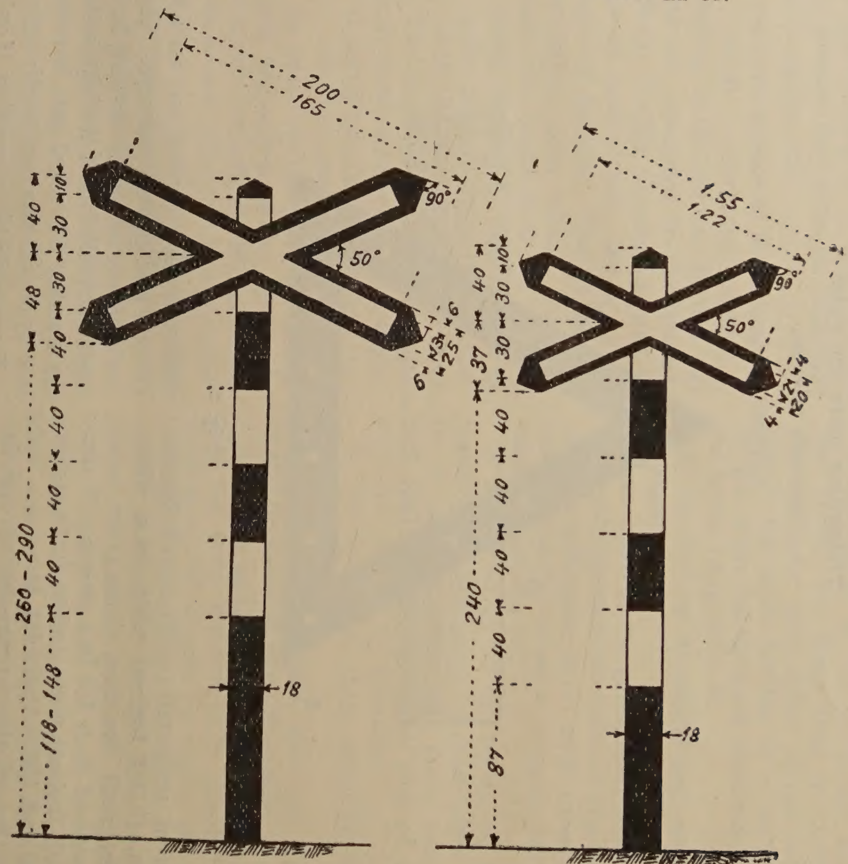



Fig. 4.

reflectors. These reflectors have been very satisfactory and have contributed materially in reducing the number of closed gates run into. The red light in the triangular plate is used principally at important level crossings in localities where the public lighting might be detrimental to the effectiveness of the reflectors. Red has been adopted as being a recognised « stop » signal.

b) *The case of optical and acoustical signalling.*

It should be pointed out that, in principle, the statutory optical and acoustical signals are generally intended to replace existing gates. In consequence, a level crossing provided with such a signal is to be regarded as if it was actually provided with gates : both are classed as *guarded crossings.* Here again the choice of the system of signalling was only decided upon after numerous and very careful tests. Automatic signals of many different types have been in operation for some years on both the Federal railways and on private lines. It was therefore a question of selecting from among these the signal which best deserved consideration, for it was clear that the desired aim could only be achieved by the uniform use of the same system of optical and acoustical signalling. It was thus necessary, in the first place, to solve a question of principle, namely, that of knowing whether it was desirable to select a *movable form of signal* or a *winking light signal.* With this object in view, simultaneous comparative tests were carried out in the presence of the representatives of the various interested parties such as the authorities, railway administrations, and automobile associations, and in unfavourable atmospheric conditions. In the course of these tests all the signals in question, namely : the pendulum signal known as the « Wig-Wag », the « Hassler » propeller signal, the « Aga » gas winking light signals, and the « Signum » electric winking light signal were brought forward and tested alongside one another. The unanimous opinion was that the « Signum » winking light signal in triangular shape with 3 winking lights was the most effective and on this account its adoption was recommended. The agreement of the supervising authority with this opinion was all the more marked owing to the fact that the system had moreover the great advantage of being identical night and day, and that, owing to the absence of moving mechanical parts, there were very small risks of the system getting of out order. The new Regulations, moreover, merely stipulate the type of signal adopted, that is to say, the pattern, and the conditions which it must satisfy, without entering into any details regarding its construction. The stipulations regarding this system are sufficiently clear and precise in themselves to render any other remarks unnecessary.

c) *The case of simple indication by means of warning signals.*

Entirely unguarded level crossings must in future be uniformly marked by a signal in the form of a cross. The directions drawn up by the International Railway Union for the protection of unguarded level crossings were final as regards the choice of the form of this signal. In the meantime, this organisation has also gone very deeply into the question of the protection of level crossings, confining itself however to those which are absolutely unguarded, and has drawn up general rules in this connexion for its members. It was in agreement with these rules that the signal in the

form of a cross was decided upon, after it had given proof of its effectiveness.

It is thus by the *form* itself of the signal that the road user will be able to know if the crossing he is approaching is *guarded* or *unguarded*. The essential feature of the new Regulations is precisely in this distinction, upon which has been based the systematic and uniform designation of level crossings : *guarded* level crossings will be uniformly provided with a *triangular* signal, and *unguarded* crossings with a signal in the form of a *cross*. When, therefore, there is a triangular signal at a level crossing it means that it is the *railway* which is informing the road user that a train is about to pass, either by closing the gates or by optical and acoustical signalling with winking lights; a crossing of this nature is *likened to a guarded crossing*, for the protection of the railway by means of a winking light signal (actuated automatically or by the railway employees) is effected in the same way as if, at the crossing, there was a guard with a flag or red lamp. It is the railway which ensures the closing of the crossing before the train arrives. If, on the other hand, the crossing is provided with a signal in the form of a cross, there is nothing to indicate the approach of a train to the road user, *who himself has to take the precaution of making certain* whether he can cross the track; such a crossing is *unguarded*. In this case, therefore, there is only an *indication* of the danger point, but not a closing (actual or signalled) of the crossing.

### Article 5.

On the other highways (where the motor traffic is light) and roads, there shall be placed, in immediate proximity to the level crossing, if possible on the property of the railway, on either side of the track, and facing the road, the *principal signals* described hereunder, forming part of the railway equipment :

a) *When there are gates :*

1. A triangular plate as stipulated in Article 4, paragraph *a*, for carriage roads.

b) *When there is optical and acoustical signalling :*

1. The supervising authority, shall decide, in agreement with the cantonal government, whether automatic signals shall be installed, taking into consideration the local conditions and the traffic.

2. When the conditions are simple, signals having merely one winking light instead of three, or merely optical signals or acoustical signals may be set up on the roads.

c) *When there is simple indication by means of warning signals :*

1. For carriage highways and roads, the small signal in the form of a cross must be used uniformly with a red border 4 cm. (1 9/16 inches) wide and a white background, the arms of which shall measure 75 cm. (2 ft. 5 1/2 in.) in length by 20 cm. (7 7/8 inches) wide, and shall make angles of 50 and 130° (Appendix 4).

2. As a general rule, a signal of this type must be placed on either side of the track if possible on the right of the road when passing the railway.

3. For roads of secondary importance, the signal may be made of smaller dimensions, and one signal will be sufficient, in place of two, set up in a suitable position near the crossing.

The same signalling devices and principles are applied to highways where the motor traffic is light and to roads not coming within the scope of Article 4, with the sole difference that, in view of the lesser importance of these roads, the use of simpler and smaller signals is allowed.

### Article 6.

1. The gates, and the supports of the winking light signals, and of the warn-

ing signals in the form of a cross, shall be painted uniformly red and white.

2. The supervising authority shall decide in each case, whether the installation of automatic gates may be authorised.

3. If the gates or automatic signals become out of order, a keeper shall be appointed instantly, or instructions shall be given for trains to pass the crossing at a speed slow enough to enable them, if necessary, to be stopped before the crossing. In addition the train shall give a warning whistle before reaching the crossing.

4. If a principal signal has to be placed on public property, an agreement shall be arrived at beforehand with the

**Appendix 5.**

**Distance posts.**

Article 7.

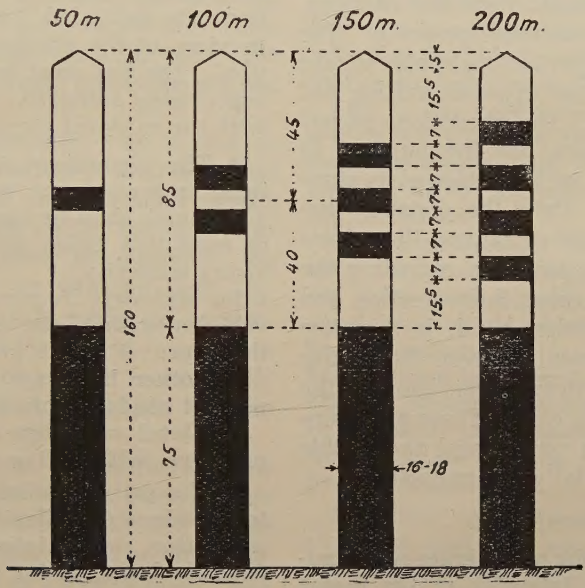



Fig. 5.

competent authorities. In the case of private property, the Federal legislation relating to expropriation is applicable.

This article does not require any comments.

Article 7.

For the purpose of indicating the distance between the advanced signal (Article 3, Section 2) and the principal signal (Articles 4 and 5) *distance posts* alone (Appendix 5) shall be used, and shall be placed along the side of the road, on the right, every 50 m. (164 feet). Each post shall have on it black bands indicating the distance between it and the level crossing.

The interested parties (railway administrations, road owners and users, etc.) shall agree together as regards the placing and maintenance of these posts.

The suggestion of searching for means suitable for indicating at different intervals to motor drivers the distance

which still separate them from the crossing, especially when the conditions of visibility are particularly unfavourable, is due to the antomobile associations. Tests showed that these requirements would best be satisfied by means of *indicating posts*. Such signalling devices, erected essentially in the interests of motor traffic, could not be installed and maintained at the expense of the railways alone, especially taking into account the fact that the posts are placed up to fairly great distances from the crossing, and outside the railway property. The other interested parties ought also to take a due share in the expenses arising out of this measure. The regulations merely stipulate, therefore, for the purpose of uniformity, that such distance posts alone may be used to show the distances between the advanced signal and the principal signal. The decisions regarding the conditions concerning their erection and upkeep, on the other hand, is a matter for direct agreement between the parties in question (railways, proprietor of the roads, road users, etc.). These posts constitute actually a very useful and visible indication, especially for motorists.

ARTICLE 8.

**In case of doubt or divergence of opinions as to the intensity of the motor traffic, the supervising authority, after having heard the competent cantonal government and the railway administration, shall give the decision in accordance with the traffic statistics and all other circumstances coming into consideration.**

It is evident that the opinions regarding the degree of intensity of the motor traffic will not be the same for all the interested parties. For this reason uniformity in the application of the Regulations requires that some authority should be appointed to decide in the matter.

ARTICLE 9.

1. The railway administration shall submit to the supervising authority, within three months from the date of the entry into force of these Regulations, a list in duplicate of the level crossings with important highways and roads which should be equipped with signals in accordance with the provisions of these Regulations. This list shall mention the intended form of signalling, in view of the present mode of protection. The list must be approved by the supervising authority, after consultation with the cantonal government.

2. The signalling of the level crossings, in accordance with the list afore mentioned, shall be carried out, a notice of execution being given to the supervising authority :

for highways frequently used by motor vehicles within one year, dating from the approval of the proposals;

for other highways and the more important roads within two years;

for level crossings of secondary importance, within five years.

3. If a railway administration intends to introduce modifications in the type of protection (substitution of optical or acoustical signals for gates, suppression of keepers, removal of gates, etc.) it should submit the plans of such changes to the supervising authority for approval. This authority shall decide in each case, after having consulted the cantonal government.

4. The automatic signals at level crossings, erected with the approval of the supervising authority before the coming into force of the present regulations and actually in use, may be retained until further notice.

5. As a general rule, the rails of the gates shall be painted red and white

when they are next re-painted, but not later than the end of 1932.

6. The arrangements employed for railway signalling at level crossings may not be used for purposes of publicity. It is also forbidden to place advertisements that interfere with the signalling.

The delays allowed for the application of the new systems of signalling take into account the importance of the roads, and naturally the systems should be installed most quickly on the main roads where the motor traffic is heaviest. The painting of the rails of the gates in red and white must also be carried out at the same time as the above-mentioned provisions are put into application.

The trials undertaken with a view to the automatic signalling of level crossings naturally required some isolated signals to be set up which do not conform with the new Regulations, for example, the pendulum signal, or winking light signals of various forms, using gas or electricity. The last-mentioned could not be straight away discarded, consequently they will be allowed to remain for the time-being.

It is of paramount importance that the effectiveness of the signals intended for indicating level crossings should be the best possible, and should not be diminished by advertising or other notices. The provisions relating to these advertisements were decreed also on the initiative of the automobile associations, which appreciated the confusion which might arise from luminous advertisements or advertisements by means of reflectors.

### Article 10.

1. In special cases, the supervising authority may, on the application of the railway administrations, authorise exemptions from the provisions aforementioned.

2. On the other hand, the supervising authority may at any time decree new measures to protect the safety of traffic.

This article does not require enlarging upon.

### Article 11.

1. In crossing the railway lines, the road users shall generally conform to the provisions of Articles 3 and 4 of the Act relating to the Policing of Railways.

2. The provisions set forth hereunder apply particularly to the crossing of railway tracks by road vehicles of all types:

*a*) If a guarded level crossing is under consideration, that is to say, one which is provided with gates or optical and acoustical signals (Article 2, Sections 1 and 2), the road vehicles must stop at a distance of at least 10 metres (33 feet) from the closed gates (Article 4, 3rd paragraph of the Act relating to the Policing of Railways.

In the meaning of the Act relating to the Policing of Railways (Art. 3 and 4), not only gates already closed shall be considered as closed gates or as barred level crossings, but also those which are being closed or opened, as also the optical and acoustical signalling laid down in Article 4, paragraphs *a* and *b*, and in Article 5, paragraphs *a* and *b*, of the present Regulations.

*b*) Before reaching unguarded level crossings, that is to say, which are only protected by signals in the form of a cross (Appendix 4) (Article 4, paragraph *c* and Article 5, paragraph *c*), the drivers of road vehicles (vehicles of all kinds) must ascertain themselves, and on their own responsibility, that no train is approaching. The track must not be crossed on the approach of a train, a set of wagons or coaches, or a light engine (Article 3 of the Act relating to the Policing of Railways.

*c*) In all cases, the track must only be crossed at walking pace (Article 4, 2nd paragraph of the Act relating to Railway Police Regulations);

*d*) On approaching a level crossing,

the speed should be reduced suitably and in sufficient time.

3. It is forbidden to damage the signals mentioned in Articles 3, 4 and 5 of the present Regulations, or to make any alteration thereto, to operate without due authority the railway protection devices placed at level crossings, and in general to commit any act whatever, capable of hindering or endangering the operation of the railway (Article 5 of the Act relating to the Policing of Railways).

The new Regulations must by all means be brought to the knowledge of the road users who have to observe them, and particularly the drivers of vehicles. It is for that reason that it was thought useful to introduce into the Regulations provisions relating to the *manner in which the road users should behave* in the neighbourhood of level crossings. The observation of these provisions will undoubtedly have as a result a reduction in the number of dangerous actions or accidents.

ARTICLE 12.

In so far as no serious fault has been shown, infringements of the provisions of Article 11 aforementioned shall be liable to the penalties laid down in Article 8 of the Act relating to the Policing of Railways.

By « serious fault » is chiefly understood any case coming within the scope of Article 67 of the Federal Penal Code, that is to say, endangering the railways, either intentionally or by negligence.

* * *

The promulgation of the regulations discussed above settles from now on in an uniform manner the question of the safety of level crossings in Swiss territory. In this instance, Switzerland has taken the initiative, which other countries of the Continent may be induced to follow, schemes for the improvement of the conditions at level crossings being everywhere under consideration. These Regulations make it compulsory for the railways to place signals at all public level crossings, which constitutes fairly heavy expenses for these undertakings; they are essentially in the interest of the automobile, a means of transport which just at the present time is competing with the railways more than any other. One is justified, therefore, in expecting that the drivers of motor vehicles will in their turn show towards the Regulations the recognition and the respect which they deserve.

As they stand, the Regulations are the result of collaboration between all the parties interested in the safety of level crossings, parties obviously not always having the same ideas. The agreement realised is due to the mutual understanding and to the great spirit of conciliation which always predominated during the preliminary investigation, the discussions, and the enquiries.

All regulations and the best designed signals remain, however, a dead letter, if they are not *observed* by those to whom they are addressed. That is why it is intended, if possible, to make all road users acquainted, by publication *ad hoc*, with the signals affecting road traffic and with the special provisions applicable to the drivers of motor vehicles when crossing railway lines at level crossings.

When the level crossings have been equipped in accordance with the regulations within the statutory periods, and the new signals are generally known and observed, a reduction in the number of accidents at these dangerous points may certainly be expected. It is hoped that very soon it will be possible to confirm this.

[ 621 .138.5 (.493) ]

# The new organisation of the central workshops at Salzinnes (Namur)(1)

(Part I),

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## I. — INTRODUCTION.

The central workshops at Salzinnes deal with the heavy repairs to the heavy types of passenger, mixed and goods locomotives; they also have to deal with the more difficult ordinary maintenance work which cannot be coped with by the depots, such as renewal or repair of broken cylinders, serious damage to frames, etc.; and, finally, they repair or make locomotive parts for the depots.

In the last few years, as a result of various circumstances, the output has proved inadequate in relation to the heavy annual expenditure and to the amount of capital invested in the installations. In 1928, for example, the expenditure, excluding amortisation, was as follows :

| | Francs |
|---|---|
| Labour . . . . . . . | 21 640 753.20 |
| Material . . . . . . . | 17 062 484.08 |
| Sundry expenditure . . | 1 533 453.95 |
| Total. . | 40 236 691.23 |

The average number of employees was about 1 270, distributed as follows : 56 % on locomotive repairs, 28 % on special orders, 16 % staff.

The output amounted only to 162 locomotives and 46 tenders, or an average of 13.5 locomotives and 3.7 tenders per month.

Further, the average period the locomotives were stopped was 80 days.

It is a most delicate task to endeavour to define the causes of such a position; so many circumstances, often outside the control of the technical staff, may have an unfavourable influence upon the output of a large workshop. We have however, considered it essential, not in a spirit of criticism but in order to give an idea of the scope of the remedies adopted, to make a concise analysis of the imperfections of the old organisation.

1. *Inadequate organisation.* — The periods of immobilisation were very long and most irregular. It is, of course, an essential condition of efficient working in a locomotive repair shop that the shop shall adhere to the programme laid down, whatever the periods fixed may be. Irregularity in turning out the locomotives necessarily causes irregularity in the distribution of work to the various sections of the workshop, which are sometimes short of work and sometimes have too much, with the result that the most effective use is not made of the personnel.

(1) Translated from the French.

In 1928 the monthly output in locomotive units fluctuated as follows, from January to December : 16, 11, 12, 11, 11, 13, 15, 16, 16, 18, 15, 8.

It will be appreciated that so irregular an output necessarily implies an imperfect utilisation of the staff.

Further, as a result of special circumstances and in particular the lack of sufficient technical staff, it was found necessary some years ago to introduce for the workmen a system of collective or participating bonuses, based on the number of locomotives leaving the workshops each type of locomotive being given a coefficient varying according to the power and complexity of the engine. This purely statistical data made it possible to draw up a monthly percentage for the bonuses, applicable uniformly to the whole staff, the amounts varying solely according to the individual rates of remuneration. This system obviously could not take account of the actual work performed by each individual and was equivalent to extra pay, which, however, provided no direct incentive to activity on the part either of individual workmen or of the gangs.

There were, indeed, individual working bonuses based on hours of work, in certain sections such as the machine tools, forges and fitting shops, but as they had no influence whatever upon the invariably uniform bonus percentage, this palliative could have only a negligeable influence upon output.

Moreover, this system of payment according to hours of work had no pretence to exactitude, as it was not based on any accurate system of time-keeping.

The machine tools had not been kept in condition or repaired as they should have been. There were no arrangements for the replacement of obsolete types or for the provision of the additional equipment required to keep pace with the growing demands on the workshop.

The situation as regards hand tools was no better : maintenance was neglected and the tools available were entirely insufficient for requirements; further, means of checking, such as calipers and gauges, were almost entirely lacking.

This situation inevitably resulted in delays in delivery of the parts manufactured in the workshops, thereby lowering the output of the repair and erection sections.

2. *Inadequate technical staff.* — Up to 1928 the management of the central workshops had been in the hands of a principal engineer who had one assistant only : an engineer or an assistant in-charge of a section.

In these circumstances it was easy for the managing officials to allow their whole time to be absorbed in the study of technical problems and in dealing with multifarious administrative and other questions, to the detriment of their principal duties, namely the organisation, supervision and control of the workshops. This situation was still further aggravated by the inadequacy of the supervisory staff.

3. *Lack of accurate accountancy data.*— The system of workshop bookkeeping in force was out of date; the checking of materials and work was scarcely under any supervision or control; the stores did not tally with the books; net costs, necessarily inexact, supplied no useful information to the technical staff with regard of the output of the workshop. Accurate bookkeeping, although obviously having no direct influence upon the output of a workshop, none the less provides the most

valuable means of control; it alone makes possible any estimation of working results and of the suitability of the organisation, the methods of working, the system of staff remuneration, etc.; in a word, it gives all the information necessary for increasing output and reducing net costs.

### II. — General plan of the new organisation.

The general outline of the new organisation is shown in Appendix 1.

The services comprise three main divisions :

1. The technical services; 2. the accounts; 3. the administrative service.

*Technical services.* — In any factory there must be the following phases, which follow one another in the order in which they are here enumerated :

1. Preliminary consideration of the work to be carried out; 2. determination of the method of working to be adopted; 3. the actual carrying out of the work; 4. checking the quality of the work when completed.

We have adopted the first three subdivisions for our technical services, the checking being included in the first subdivision. The services therefore comprise :

1. *The general technical service*, the organisation of which is shown in detail in appendix 2. It will be seen that there are three sections :

The *drawing office* section which deals with : *a*) modifications to locomotives, standardisation of parts, fittings and dimensions, the fixing of limits and gauges, technical specifications, workshop technology and various tests; *b*) the design of machine tools and hand tools, installations in general and maintenance equipment;

The section : *installations and tools*, which deals with the whole service of tool equipment : erection and maintenance of machine tools and various appliances, the making, maintenance, distribution and inspection of hand tools, the testing of steels tools, etc.;

The section: *supervision of work*, which exercises systematic supervision over the work in all sections of the workshop as regards : materials, dimensions, workshop limits, fitting, erection, repair methods, etc.

2. The *works office*, the organisation of which is shown in table form in Appendix 3.

The functions of this office are :

*a*) To *prepare the work*. For this purpose it prepares tables laying down the sequence of operations to be followed in the making or repairing of all parts and objects; it prepares instruction sheets for the various types of normal work; fixes and checks the timing on which working bonuses are calculated; prepares inventories, estimates and repair sheets in close collaboration with the workshop service.

*b*) To prepare following up slips, work vouchers, vouchers for materials entering and leaving the stores; to arrange and to supervise the checking of both gang work and individual work.

*c*) To prepare detailed time sheets for the making of all parts and objects in accordance with the programme laid down by the workshop management; to keep daily record sheets showing the progress of work; to arrange for the regular distribution of work among the machine tools, etc.

*d*) To control the movement of ma-

terials and parts from the stores to the appropriate sections of the workshops, within the sections themselves, and from one section to another. As the inventories, estimates and forwarding slips, as well as vouchers for materials, are prepared by the works office, it is reasonable that the whole of this movement service should be undertaken by that office.

3. *The workshop service*, the organisation of which is shown in the table given in Appendix 4. The workshops have been divided into three main sections, each under the control of an engineer or of a chief workshop foreman : 1. erection, 2. boiler construction and, 3. forges, foundries, fitting and machine shops. Each section is further divided into sub-sections under the control of foremen and specialist gang foremen. The chief workshop foreman, who is in charge of the erection section, is also responsible for general discipline in all sections.

*Accounts.* — The *accountancy* service, the organisation of which is shown in the table in Appendix 5, fulfils a very important role in the workshops, its importance being in direct ratio to the expenditure incurred.

We have seen that for the year 1928 this expenditure exceeded 40 million francs. The figure for 1929 will show a considerable increase as a result of the very rapid increase in production and, consequently, in the expenditure on materials.

The accountancy service has been so organised as to ensure complete control over all expenditure : materials, labour and general expenses; net costs; staff output, etc. The service comprises three sections :

*Stores*, which in turn comprise three sections : purchases, stores proper, and stores accounting; deliveries to the workshop and the outside departments.

*Cost prices*, with the sub-divisions : wages, materials and cost prices properly speaking.

*Centralisation*, the principal function of which, apart from centralisation proper (general accounts) and the control of wages, is to prepare diagrams and statistics relative to net costs, general expenses, bonuses, production, staff output, etc.

**Administrative service.** — The administrative services deal in the main with all questions relating to the staff : engagement, wages, allowances, increases, medical service, sickness pay, pensions, etc.

In the table in Appendix 6, the component parts of the locomotive have been divided into a series of groups on the decimal classification : this division has been adopted for the classification of plans and documents in the drawing office, for the calculation of net costs, for the classification of stores, for the drawing up of operation tables in the works office, for fixing the duties of the workshop supervisory and control staff, etc. This arrangement ensures complete co-ordination of the services and considerably simplifies enquiries.

Having now explained the broad outlines of the general scheme of organisation, we shall, in the succeeding chapters, examine in detail the duties falling to each service.

APPENDIX 1.

## Central Workshops at Salzinnes.

### Organisation.

- **MANAGER . .**
  - Technical services. Assistant Manager.
    - General technical service. 1 Engineer.
      - Drawing office; tests.
      - Installations; tools.
      - Checking quality of finished work.
    - Works Office. 1 Engineer.
      - Preparation of work; estimates.
      - Checking.
      - Progress of work.
      - Movement of materials.
    - Workshop service. 1 Engineer.
      - Chief workshop foreman. . . . . Erection.
      - Engineer. . . . . . Boilermaking.
      - Engineer . . . .
        - Foundries.
        - Forges.
        - Machine tools.
        - Fitting.
        - Yard; electric service.
  - Accounts. 1 Accountant . . . . . . . .
    - Bookkeeper . . .
      - Stores.
      - Orders; dispatching.
    - Bookkeeper . . .
      - Calculation of net costs.
      - General bookkeeping.
      - Cash.
    - Bookkeeper . . .
      - Checking.
      - Diagrams.
      - Statistics.
  - Administrative service. 1 Chief clerck. .
    - Staff.
    - Medical service.
  - Secretariat. 1 Technical inspector.

APPENDIX 2.

## Organisation.

- **General technical service.** Engineer.
  - Preliminary studies. Chief draughtsman deputy chief draughtsman.
    - Alterations to locomotives.
    - Standardisation.
    - Technical specifications.
    - Workshop technology. Tests.
    - Machine tools and hand tools.
    - Investigations, plans, tests.
    - Installations, transports.
    - — Draughtsmen.
  - Installations and tools. 1 foreman 1 gang foreman.
    - Erection and maintenance of machine tools, appliances and installations.
    - Manufacture, maintenance, distribution and control of tools.
    - Testing of steels, tools, etc.
    - — Leading workmen, workmen.
  - Checking of work. 1 foreman.
    - Erection. 1 gang foreman.
      - Frame and brake. — 1 inspector.
      - Driving gear. — do.
      - Boiler and fittings. — do.
    - Boilers. 1 gang foreman.
      - Stripping, inspection, making of plates and fittings. Re-erecting. — do.
      - Staybolts, stays, rivets, caulking. — do.
      - Tubes, staying and packing. — do.
    - 1 gang foreman.
      - Machine tools.
        - Parts in general use, bolts, rings, pins, etc. — do.
        - Frame, spring gear, brake. — do.
        - Driving gear. — do.
        - Boiler and fittings. — do.
      - Fitting.
        - Rods, lever, driving gear. — do.
        - Fittings and taps. — do.
      - Forges. — do.
      - Foundry. — do.

APPENDIX 3.

## Organisation.

| | | | |
|---|---|---|---|
| **Works Office.** Engineer. | Preparation of work. | Operation tables, instruction sheets for various types of repairs and manufacture.<br>Timing, allowances.<br>Inventories and repair sheets.<br>Estimates. | 3 gang foremen and staff. |
| | Checking. | Forwarding slips.<br>Work vouchers.<br>Vouchers for materials entering and leaving stores.<br>Checking. | Erection . . . 1 gang foreman<br>Boiler making do.<br>Machine tools, fitting, etc. do.<br>Shop clerks and checkers |
| | Progress of work. | Time sheets.<br>Progress sheets.<br>Table showing allocation of machine tools. | |
| | Movement of materials. | Movement of materials from stores to workshop sections and between sections. | 1 foreman, labourers. |

## Organisation.

| | | | | |
|---|---|---|---|---|
| Workshop's service. 1 Engineer. | Erection. 1 chief workshop official. | Re-erection; tests. 1 foreman. | Frame, spring gear, brake; driving gear. | 1 gang foreman. |
| | | | Boilers; tubes, fittings. | do |
| | | | Tests and re-adjustments. | do |
| | | Stripping; special gangs. 1 foreman. | Stripping; plates; sanding gear; ash pans. | do. |
| | | | Fireboxes; pistons and valves, spring gear, brake, wheels, bogies | do. |
| | Boilers. 1 Engineer. | 1 foreman. | Marking off; plate forging and machine tools. | do. |
| | | | Stripping; re-erecting; boring, tapping; fitting of staybolts and stays. | do. |
| | | | Rivetting, packing. Bracing. Testing, re-adjusting. | do. |
| | | | Tubes; pre-heaters; special driving systems. | do. |
| | Forges, foundry, workshop. Auxiliary services. 1 Engineer. | Fitting. 1 foreman. | Rods, driving gear levers. | do. |
| | | | Brasswork. Grinding machines; lathes; milling machines; tap turning machines. | do. |
| | | | Copper smithy; white metalling. | do. |
| | | Foundry. | Iron foundry. Brass foundry. | do. |
| | | Machine tools. 1 foreman. | Milling machines; shapping mach. Planing mach.; slotting machines. | do. |
| | | | Lathes, capstan lathes, borers, drills, tapping machines. | do. |
| | | Forges. 1 foreman. | Main forge; boiler, driving gear; various parts. | do. |
| | | | Frame; brake; spring gear; case hardening various parts. | do. |
| | | Yard service: Shunting; stores, etc. | | do. |
| | | Electric service: Inspection; maintenance. | | do. |

APPENDIX 5.

## Organisation.

- **Accountancy.** Accountant.
  - Stores. Bookkeeper.
    - Purchases. Employees.
      - Estimates; purchases.
      - Inspection; payment orders.
    - Bookkeeping and stores. Employees.
      - Journals; invoice book; balances; invoices; personal accounts.
      - Valorisation of invoices.
      - Bookkeeping slips.
        - Employees operating bookkeeping mac hines
      - Materials delivered to and issued from stores; stores vouchers; despatches.
        - Storekeepers and labourers.
    - Orders. Employees.
      - Filing of orders for workshop and external services.
      - Filing of orders.
  - Net costs. Bookkeeper.
    - Salaries. Employees.
      - Labour : control of checking; individual slips; order slips; calculation of bonuses; salary lists.
    - Materials. Employees.
      - Materials; checking of vouchers; order sheets, etc.
    - Net costs. Employees.
      - Net costs; invoices; journals; personal accounts.
      - Balances.
      - Inventories.
    - Employees operating bookkeeping machines.
  - Centralisation. Bookkeeper.
    - Employees.
      - General account; checking of salary lists; cash; statistics and diagrams of net costs, of general expenses, of bonuses, etc.
      - Control of valuable metals.

APPENDIX 6.

## Organisation.

### Decimal classification of locomotive parts.

1. Boiler.
   1. Firebox, boiler barrel and smoke box.
   2. Tubes and superheater elements.
   3. Firebox doors, grates and ashpan.

2. Fittings.
   1. Water feeding devices, pumps, pre-heaters.
   2. Safety devices.
   3. Sundry accessories : whistle, blower, change over valve, blow down cock, wash-out holes. etc.

3. Frame.
   1. Frame proper : drag boxes, frame stays, strengthening pieces.
   2. Draw and buffer gear.
   3. Suspension : springs, equalisers and their brackets.
   4. Axles, wheel centres, tyres, retaining rings, axle boxes, journals, keeps, horn sheets, fittings; arrangements to facilitate running round curves.

4. Driving gear.
   1. Regulator.
   2. Cylinders and accessories.
   3. Pistons, cross-heads and guides.
   4. Connecting rods and coupling rods.
   5. Steam distribution details.
   6. Exhaust.

5. Brake.

6. Accessories.
   1. Lubricators, tube cleaning appliances.
   2. Tubing, piping and accessories.
   3. Boiler lagging, sanding gear, bunkers.

[ 621 .132 8 & 656 .22 ]

# REPORT No. 2

(**All countries except America, the British Empire China, Japan, Belgium, France, Italy, Portugal Spain and their Colonies**),

ON THE QUESTION OF ECONOMICAL TRACTION METHODS FOR USE IN PARTICULAR CASES (SUBJECT XII FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1) (2),

By H. HUNZIKER,

GENERAL MANAGER OF THE RAILWAY SECTION OF THE FEDERAL POSTS AND RAILWAYS DEPARTMENT, BERNE.

Figs. 1 to 12, pp. 2860 to 2874.

## A. — Organisation of train services on the minor lines of the large systems carrying little traffic and of little used trains on the more important lines of these systems.

*The Netherlands State Railway Company and the Dutch Railway Company* give the following information :

In addition to 35 light steam locomotives, 13 petrol rail motors and 8 Diesel rail motors have been in service for a short time. It is proposed to purchase later on bogie petrol rail motors including second and third class compartments or four wheeled similar vehicles carrying third class only (figs. 1 and 2). The motors of all these vehicles are six cylindered and their power is about 70 to 75 H. P. each. Each rail motor is fitted with two such motors so that the total power is from 140 to 150 H. P. The power is transmitted mechanically.

The average number of the trains varies according to the distances, between 16 and 40 in the case of steam operation, and between 18 and 33 when operating with rail motors.

The number of seats required in each train is from 42 to 148 according to the section of line.

(1) This question runs as follows : « *Economical traction methods for use in particular cases, as for example :*

*A*) Organisation of train services on the minor lines of the large systems carrying little traffic and of little used trains on the more important lines of these systems.

*B*) Use of special tractors for shunting in smaller yards and for certain work in large yards. »

(2) Translated from the French.

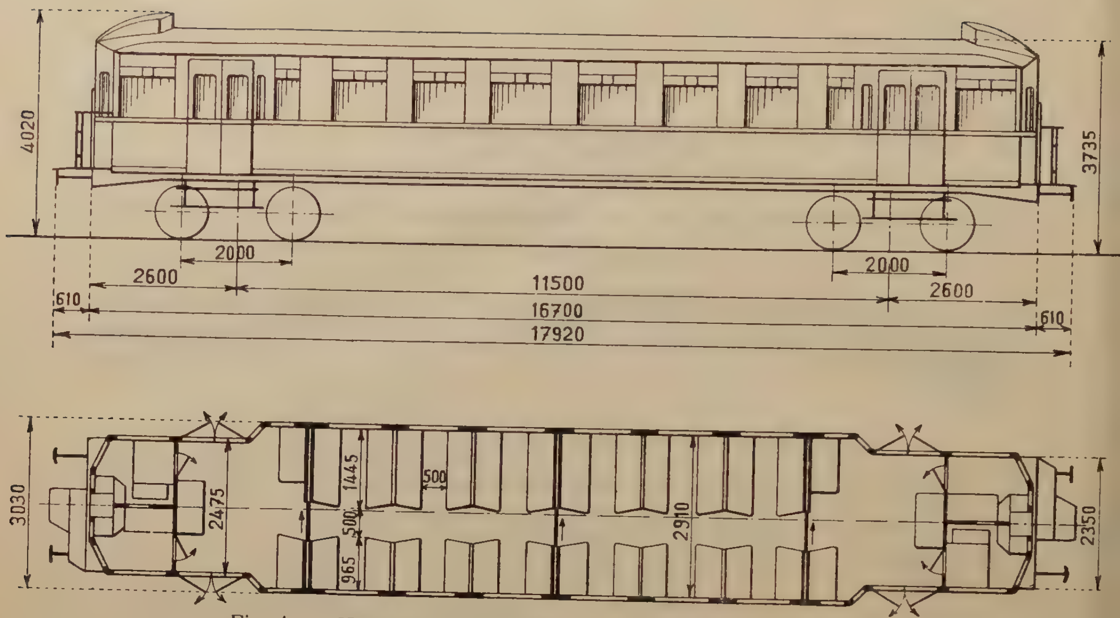


Fig. 1. — Netherlands State Railways. — Benzine rail motor coach.

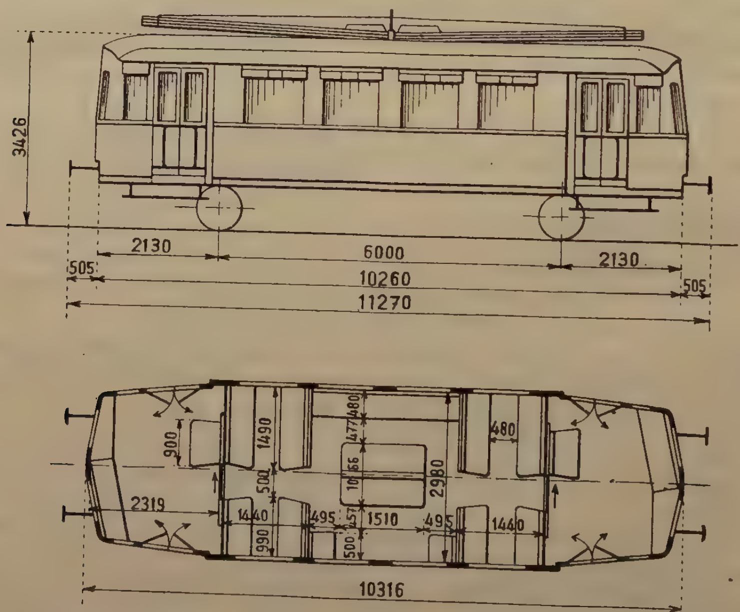


Fig. 2. — Netherlands State Railways. — Benzine rail motor coach.

As a general rule it should be possible to work with rail motors which are cheaper, lines operated by steam except of course certain sections with heavy summer traffic or with many season ticket holders (workmens' trains).

The maximum speed of the trains is about 45 km. (28 miles) per hour for steam working, whereas it varies between 45 and 70 (28 and 43.5 miles) in the case of services worked with rail motors.

The steam locomotives are handled by one or two men according to the gradient of the line; in addition each train carries a ticket examiner. As a rule, the rail motors are worked by one man alone, but a ticket examiner is added as soon as the train consists of more than one vehicle. For safety reasons when handled by one man the rail motors are fitted with a device by means of which the brakes come into action as soon as the driver releases the driving handle (arrangement known as the « dead man's handle »).

The conditions of service are the same as regards length of hours on duty for the staff of trains running over little used lines as in the case of those working on the main lines; the turn of duty may be extended to 12 hours per day.

The trains with rail motor coaches are as rule formed with only the rail motor itself or of two rail motors with a brake van between them; as a rule they have third class compartments only.

There is little possibility of using rail motor coaches for hauling heavy trains; in the case of rushes of passengers, this has to be met by coupling together two rail motors or by using a steam locomotive.

As regards the danger of fire, rail motors are stabled in special sheds; a specially trained staff is responsible for their maintenance.

The consumption of combustible is from 4.2 to 7.6 kgr. of coal per km. (14.9 to 27 lb. per mile) for the locomotives and 0.37, 0.95, 1.17 litres of benzine per km. (0.13, 0.33 and 0.41 gallon per mile) for the petrol rail motors. The cost of combustible amounts to 1.09-2.0 gold-francs per train-kilometre (1.75 to 3.22 gold-fr. per mile), for steam traction and to 0.21-0.25 gold-franc per train-kilometre (0.34-0.40 gold-franc per train-mile) when operating by petrol motor; these costs amount to 0.029 gold-franc per train-kilometre (0.047 gold-franc per train-mile) when using Diesel motors.

0.75 gold-franc per 100 kilometres (1.21 gold-fr. per 100 miles) are expended for lubrication materials on the steam locomotives, and from 1 to 2.8 gold-francs (1.61 to 4.50 gold-fr. per 100 miles) for the rail motors according to the type.

The cost of the rail motors is from 96 000 to 132 000 gold-francs according to the type; depreciation is spread over a period of 13 years.

The mileage run per annum is from 19 000 to 30 000 km. (11 800 to 18 650 miles) for the steam locomotives, and from 32 000 to 60 000 km. (19 900 to 37 300 miles) for the rail motor coaches.

Finally, it should be mentioned that in view of the light traffic on one of the lines the operating on the railway has been replaced by a service of road motor omnibuses.

*The Royal Swedish State Railways Administration* advises us as follows :

The trains are worked by steam locomotives both on little important lines as on the main lines. Explosion or internal combustion locomotives are not used, nor are there any accumulator locomotives; on the other hand there are three rail cars with explosion motors

in service. The latter are fitted with six-cylinder engines of 160 to 260 H. P. with mechanical transmission.

The total weight of these vehicles is 22 tons for 60 seats.

These rail motor coaches are driven by a single man, provided no trailer is attached. As a safety measure the rail motor coaches are fitted with the automatic arrangement known as « the dead man's handle ». When operated by a single man the tickets are dealt with by the station staff before the train leaves. When trailers are attached to the trains a ticket examiner accompanies the driver.

The working conditions of the staff are the same on lines with little traffic as on the main lines; the minimum day's work is 7 1/2 hours, and the maximum 13.

The rail motor coaches are of one class alone.

The rail motors stand in the ordinary locomotive depots and are maintained and looked after by special staffs.

The consumption of combustible amounts to 0.45 litre of benzine and 15 grammes of oil per kilometre (respectively 0.16 gallon and 0.85 ounce per mile); the cost per train-kilometre is on the average :

0.27 gold-franc (0.43 gold-fr. per mile) for fuel; and 0.2 gold-franc (0.32 gold-fr. per mile) for lubrication material.

*The General Management of the Danish State Railways* reports as follows :

No steam locomotive of special construction is employed for working lines with little traffic; on the other hand 6 Diesel locomotives, 22 benzine rail motors and 4 Diesel rail motors are in service. Seeing that these motor vehicles were only purchased in the years 1925-1928, there is still too little infomation on the experience obtained with these machines for any conclusive information to be supplied.

The locomotives with Diesel motors and electric drive have 4 driving axles the same as the Diesel rail motors. The benzine rail motors built in three different sizes have two or three pairs of wheels (figs. 3, 4 and 5).

The Diesel motors like the benzine motors have 6 cylinders; the former are of 230 H. P. and the others 100. In the case of the Diesel rail motors power is transmitted electrically, and in the case of the benzine rail motors, mechanically.

The Diesel rail motor coaches weigh 42 to 44 tons empty, and about 90 tons when fully loaded. The empty weight of the benzine rail motor coaches is 11, 13.5 and 19.3 tons; and when fully loaded 20, 40, and 57 tons respectively.

The distance run daily amounts to 450 km. (280 miles) for the Diesel locomotives and to about 200 km. (124 miles) for the benzine rail motor coaches.

The usual make up of a train is a Diesel locomotive, and one or two trailers, that is a load of about 60 tons, or two benzine rail motor coaches weighing about 30 tons. The weight of the train can also be increased within certain limits. The Diesel electric locomotives of class M 101 to 106 can haul as many as 16 carriages corresponding to a load of 160 tons, the Diesel electric rail motor coaches up to 8 wagons weighing 80 tons and the benzine rail motor coaches up to 40 tons. When it is necessary to work heavier loads steam locomotives are used.

The rail motor coaches are driven by one man.

Both the locomotives and the rail motor coaches are fitted with the automatic safety device which acts as usual upon the brakes and upon the motors. The trains

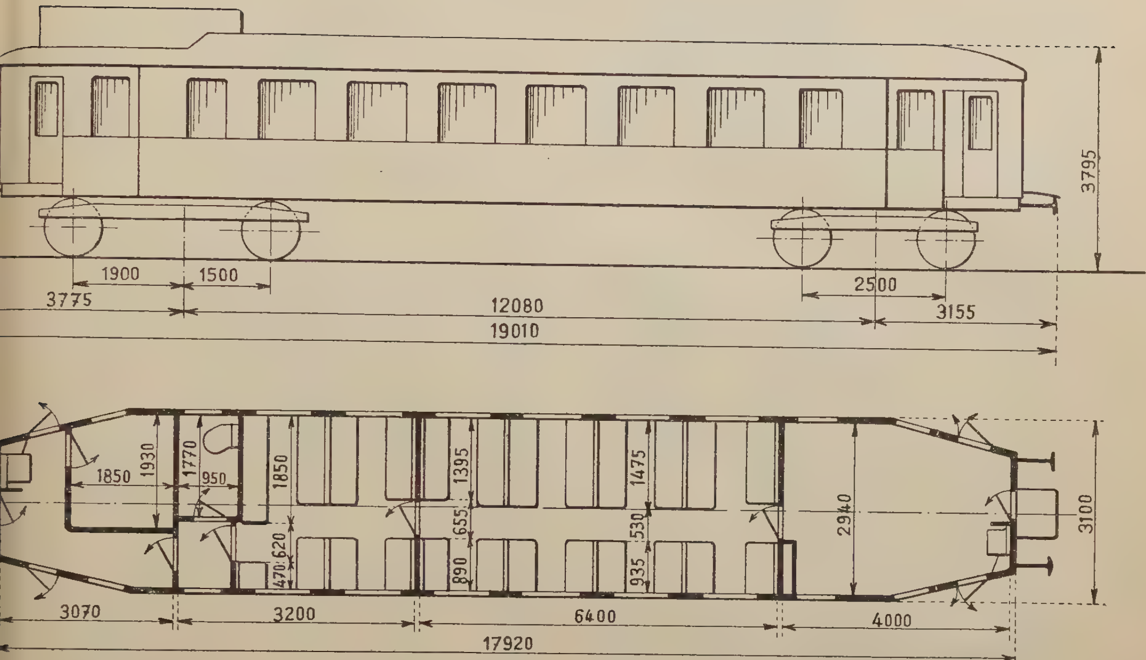


Fig. 3. — Danish State Railways. — Diesel-electric rail motor coach.

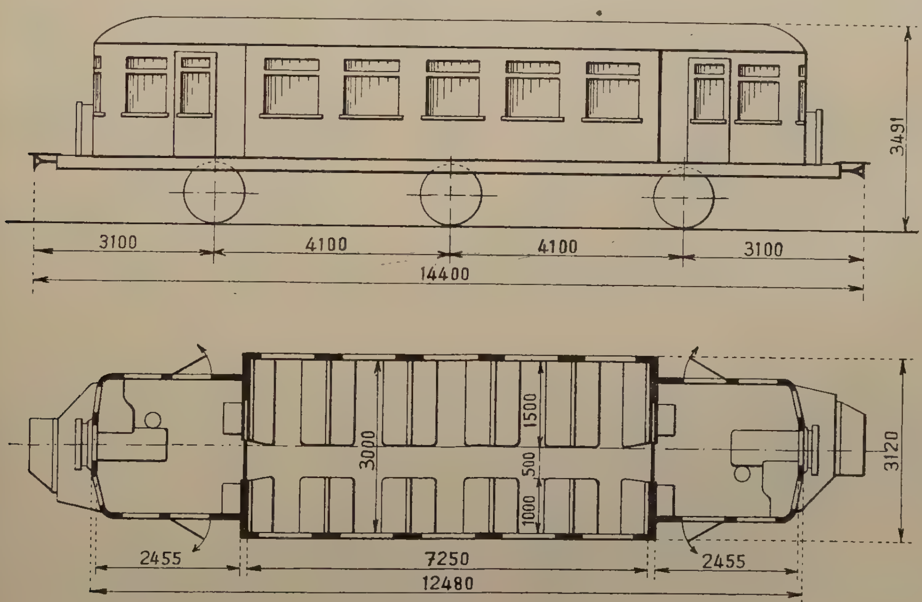


Fig. 4. — Danish State Railways. — Benzine rail motor coach.

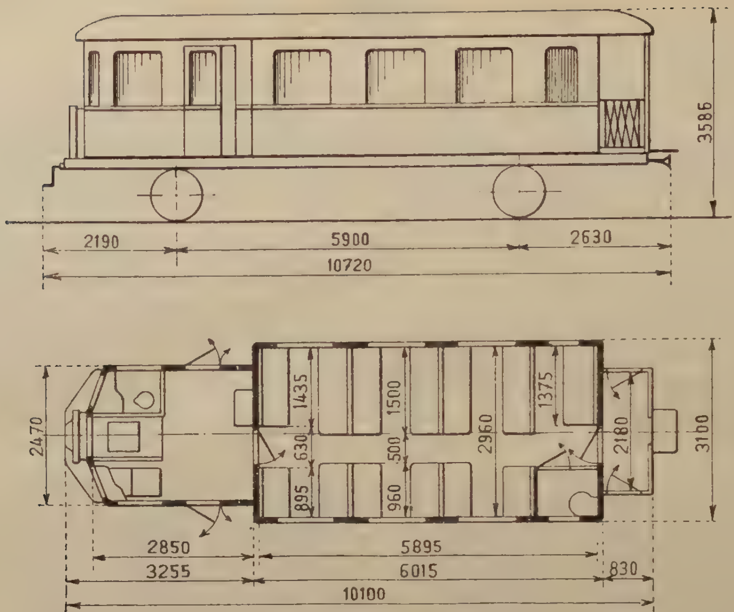


Fig. 5. — Danish State Railways. — Benzine rail motor coach.

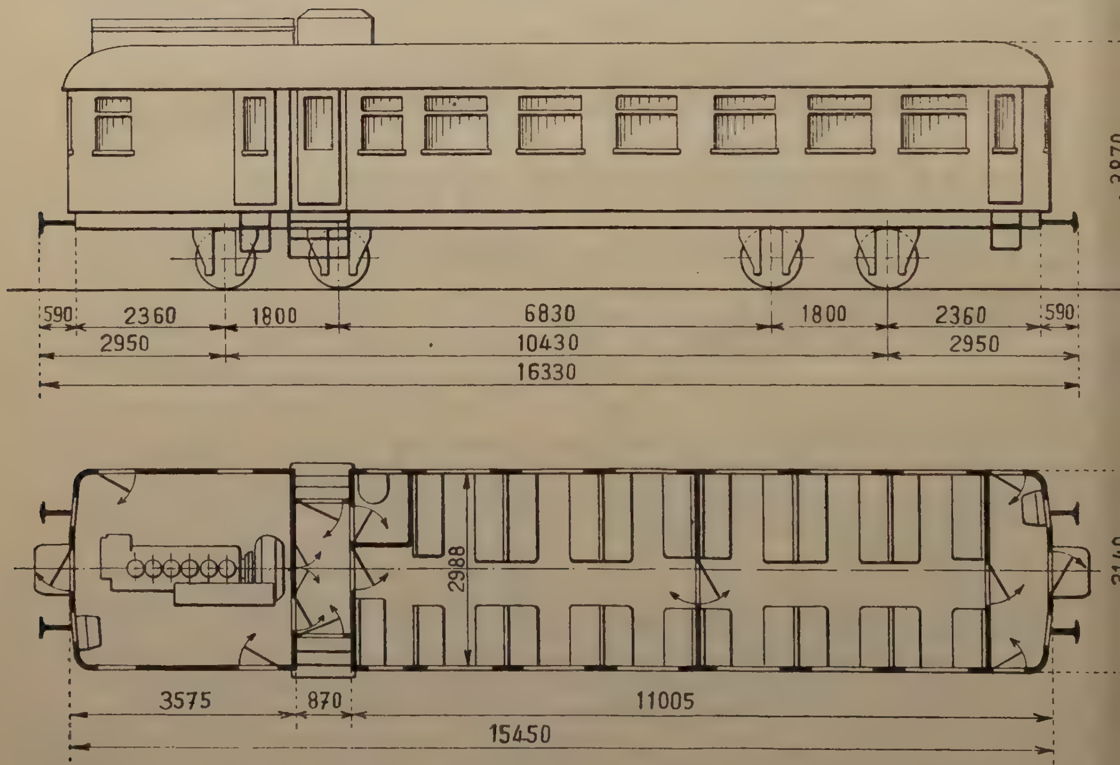


Fig. 6. — Finnish State Railways. — Diesel-electric rail motor coach.

still carry 1 or 2 men in addition to the driver. Working with a single man has only been introduced upon one line; carriages without staff are not allowed to run on such trains.

The working conditions of the staff are the same on the secondary lines as on the main lines.

The Diesel locomotives like the Diesel rail motor coaches have a driver's compartment at each end, some of the benzine rail motor coaches being arranged in the same way, while others have a driver's compartment at one end only.

The running speed of these vehicles is fixed at 70 km. (43.5 miles) per hour as a maximum.

The Diesel electric locomotives as also the different sorts of rail motor coaches are stabled in the ordinary locomotive sheds.

The consumption of combustible by the locomotives is on the average 800 grammes per kilometre (1.76 lb. per mile), that of the Diesel rail motor coaches 600 grammes per kilometre (1.32 lb. per mile), and that of the benzine rail motor coaches 400 grammes (0.83 lb. per mile). The distance run annually by the rail motor coaches both those with Diesel engines and those with benzine motors amounts to about 270 000 train-kilometres (166 800 train-miles) per unit.

No difficulty has been experienced so far from the fact that the rail motor coaches have very little spare capacity.

Seeing the appreciable saving that they have secured in operation it has been decided to extend the use of Diesel and benzine rail motor vehicles.

*The General Management of the Finnish State Railways* reports as follows :

In addition to light steam locomotives there are in service two benzine rail motor coaches of 75 H. P. per motor and a Diesel rail motor coach of 90 H. P., all built in 1927.

The operating results obtained so far with these vehicles are satisfactory.

The Diesel rail motor coach has four, and the petrol, two pairs of wheels. The tare of the first is 33.2 tons, and that of the benzine vehicles 20.5 tons (fig. 6).

Owing to the short time these vehicles have been in service no other statistical information can be given concerning them.

*The General Management of the State Railways of the Kingdom of the Serbs, Croates and Slovenes,* advises us that :

377 locomotives of classes 0-C-0 or 1-C-1 or 1-C-0 are in use on lines with litttle traffic. In addition 103 steam locomotives of medium power of the 2-B-0 class are used for working light trains running over more important lines.

In addition, tests are at the present time being carried out with two benzine rail motor coaches with the idea of replacing steam working by a more economical system. This question being still in the experimental state it is not possible to give at the present time any more definitive information.

*The Ministry of Railways of the Czecho-Slovakian Republic* reports that as regards the State Railways :

For passenger trains on unimportant lines with little traffic as well as for small trains on more important lines in addition to the 10 steam rail motor coaches of different systems in use, there are 10 benzine rail motor coaches built during the years 1925-1928.

Most of these rail motor coaches have four pairs of wheels.

In addition 53 motor omnibuses with four wheels for working on the railway lines are in service. Six small benzine rail motor vans are used to carry papers between the towns and the main junction stations.

The steam rail motor coaches of old construction should not be put into the working in future as the maintenance of the boiler is very costly, their power insufficient, and as they are worked by two men they are too costly. They should be replaced by benzine rail motor coaches with either electrical or mechanical transmission.

The rail motor coaches in service are as a rule fitted with six-cylinder motors the power of which varies between 40 and 150 H. P. The energy is transmitted mechanically, except in the case of one rail motor in which it is done electrically.

The running speed varies between 45 and 70 km. (28 and 43.5 miles) per hour according to the type of vehicle.

The empty and loaded weights are very different; the weight of the former oscillates between 2.8 and 36 tons and the others between 5.8 and 44 tons.

The maximum distances run by these rail motor coaches is 366 km. (227 miles) per day. They run on the average about 300 km. (186 miles), whereas the steam rail motor coaches did not do more than 100 to 150 km. (62 to 93 miles).

Sixty per cent of the rail motor coaches and motor buses are in service each day.

The rail motor coaches are handled by one man, but in addition there is a travelling ticket examiner. Driving by one man is only done on lines with little traffic, and in the case where no trailer is worked. Safety devices are fitted should the driver fail for any reason.

The working conditions are in all cases the same as for the staff on the main lines. The day's work should not as a rule exceed 192 hours over a space of 4 weeks. The period of work (including preparation) can be increased to 9 hours per day, as the maximum, for through trains, to 11 for stopping trains, to 12 for goods trains and shunting, and finally to 16 in the case of light railways. In the case of operation by means of benzine rail motor coaches the period of duty is reduced as compared with steam operation.

The rail motor coaches only carry third class passengers and have a capacity of from 50 to 80. As a rule one to two empty carriages or one brake van can be attached to them; in the first case the number of seats is about 160 per train.

The rail motor vehicles are as far as possible stabled in special sheds, or in the locomotive depots; in the latter case however, locomotives lighted up cannot stand in the same shed. The rail motor coaches are driven and maintained by a specially instructed staff.

The maximum speed of the rail motor coaches is from 40 to 50 km. (25 to 31 miles) per hour on the secondary lines and 80 km. (50 miles) on the main lines; that of the steam rail motor coaches is usually 40 to 50 km. (25 to 31 miles) per hour.

The table below gives more detailed information as regards the cost of operation of the different types of rail motor coaches :

| | Fuel | | Lubricating materials | |
|---|---|---|---|---|
| | Train-km. (Train-miles). | Tonne-km. (Engl. ton-miles). | per train-km. (per train-mile) | per tonne-km. (per Engl. ton mile). |
| Expenditure expressed in : | Gold-francs. | Gold-francs | Gold-francs. | Gold-francs. |
| « Skoda Sentinel » steam rail motors . | 0.184 (0.296) | 0.0047 (0.0077) | 0 0188 (0 0302) | 0.0004 (0 00065) |
| Rail coaches with explosion motors . . | 0.276 (0.444) | 0.0068 (0 011[illegible]) | 0.0368 (0.0592) | 0.0092 (0.0150) |
| Rail omnibus with explosion motors. . | 0.146 (0.235) | 0.0073 (0 0119) | 0.0159 (0 0256) | 0 0084 (0.0137) |
| Small rail motors transporting newspapers . . . . . . . . . . . . | 0.092 (0.148) | 0.0092 (0.0150) | 0.0188 (0.0302) | 0.0188 (0.0307) |

The average cost price has been as follows :

| | Gold-francs. |
|---|---|
| Rail motor coaches with explosion motors . . | 122 600-153 000 |
| Motor omnibuses on rails . . . . . . | 26 000- 38 000 |
| Small rail motor coaches . . . . . | 21 000 |
| Steam rail motor coaches . . . . . | 92 000 |

As regards amortisation these vehicles have been given a life of 5 to 10 years for the rail motor coaches, and 20 years for the steam rail motor coaches.

The distance run annually in round figures amounts to 40 000 km. (25 000 miles) for the motor omnibuses running on rails and the benzine rail motor coaches, 50 000 km. (31 000 miles) for the small rail motor coaches 24 000 km. (15 000 miles) for steam rail motor coaches, and 30 000 km. (18 600 miles) for the steam locomotives.

*The General Management of the Swiss Federal Railways* has given the following information :

Operation by means of light rail motor coaches is limited to certain isolated lines. Upon the electrified lines electric motor coaches are used and also locomotives of class BC*e* 4/4, F*e* 4/4 and D*e* 6/6, built during the years 1910, 1911 and 1926. In addtion two benzine rail motor coaches and one Diesel electric rail motor coach are in use. The purchase of further benzine rail motor coaches is not under consideration as the capacity of these vehicles has shown itself to be inadequate in many cases.

The locomotives of class D*e* 6/6 have 6 driving axles, the benzine rail motor coaches one driving axle and one carrying axle, the Diesel rail motor coaches 2 driving axles and 2 carrying axles (figs 7 and 8).

The motors of the vehicles not driven by electricity have 8 cylinders; the power is from 100 to 120 H. P. for the benzine rail motor coaches and 250 H. P. for the Diesel rail motor coaches. The power is transmitted mechanically.

The tare weight of the benzine rail motor coaches is 21.1 tons and their gross weight 25.8; for the Diesel rail motors the corresponding figures are 55 and 61 tons respectively.

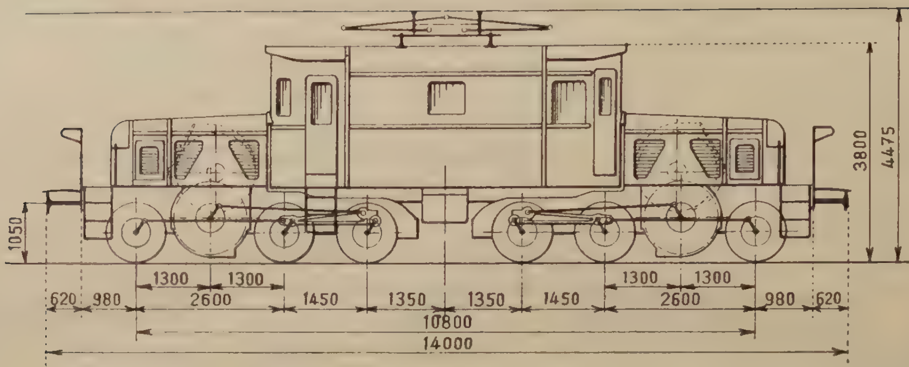


Fig. 7. — Swiss Federal Railways. — Electric locomotive.

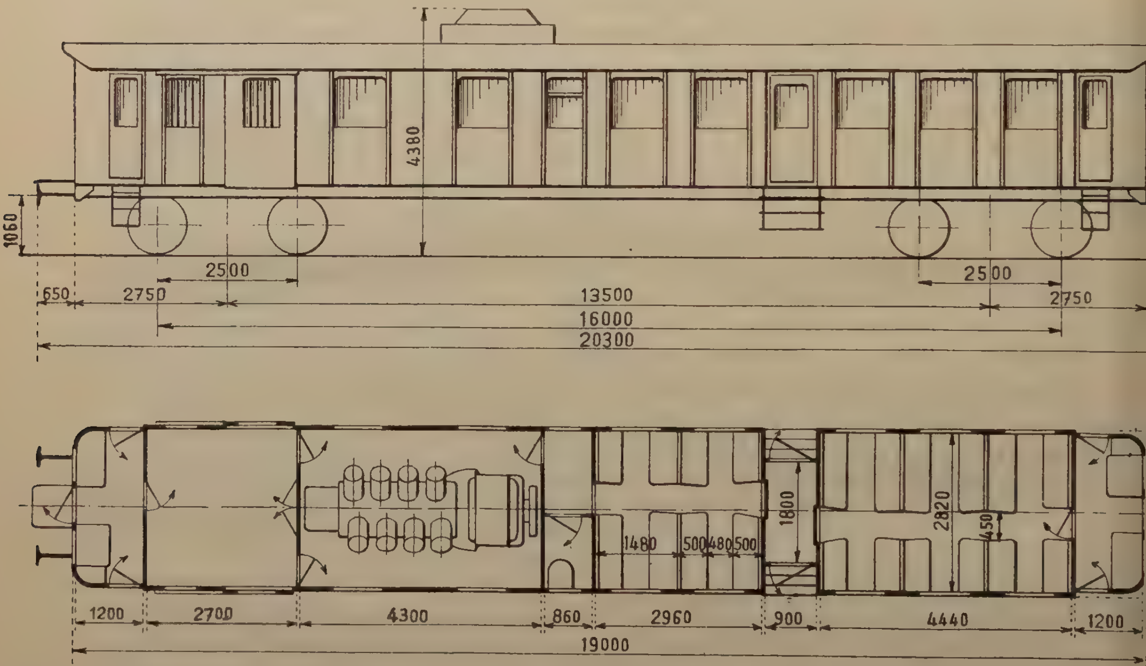


Fig. 8. — Swiss Federal Railways. — Diesel-electric rail motor coach.

The total number of train-kilometres run in a year with these vehicles is in round figures 700 000 (435 000 train-miles); the daily number of trains worked is 38 for the electric rail motor coaches, 12 for the benzine, and 8 for the Diesel rail motor coaches, corresponding to 822, 196, and 206 train-kilometres (511, 122 and 128 train-miles). The average runnings speed is 22 to 44 km. (13.7 to 27.3

miles) per hour, and the maximum speed is 45 to 75 km. (28 to 46.6 miles) per hour.

The composition of these trains as a rule consists of 1 to 2 C or BC coaches and if need be, a luggage brake; the load is 22 to 50 tons according to the line run over.

There are in daily service: four BC*e* 4/4, one F*e* 4/4, one benzine rail motor coach, one Diesel-electric rail motor coach and also one locomotive. It is not proposed to increase the stock of these rail motor coaches for the present.

The Diesel rail motor coach is arranged so as to be driven by one man and is fitted in consequence with a safety device.

The number of hours on duty of the staff is 15 at the maximum and the working day is 10 hours; no distinction is made between secondary and main lines.

The benzine rail motor coaches are only suitable as a rule for working on lines with a constant light traffic; as soon as exceptionnal circumstances occur, such as for example a sudden rush of passengers, or the movement of fast goods wagons, it is necessary to use a suitable steam locomotive because the tractive power of the rail motor coach is inadequate. The Diesel rail motor coaches adapt themselves a little more easily to the needs of the traffic; the greater power of the motor as well as the possibility of supercharging the Diesel motor make it possible if need be to strengthen the normal make up of the train by a light vehicle, or by a goods wagon.

The rail motor coaches are stabled in the ordinary depots: they are operated by a specially instructed staff.

The consumption of combustible is, for the rail motor coaches using benzine, 0.56 kgr. per km. (1.98 lb. per mile) which represents a cost of 0.31 fr. (0.50 fr. per mile); for the Diesel rail motor coaches it amounts to 0.10 gold-fr. (0.16 gold-fr. per mile).

The consumption of lubricating materials is 11.4 grammes per km. (0.65 ounce per mile).

The purchase price of these vehicles is as follows :

| | | | |
|---|---|---|---|
| Passenger rail motor coaches . . . . | BC*e* 4/4 | 98 000 gold-francs. | |
| Rail motor vans . . | F*e* 4/4 | 73 000 | — |
| Benzine rail motor coaches . . . . | CF*m* 1/2 | 135 000 | — |
| Diesel rail motor coaches . . . . | CF*m* 2/4 | 285 000 | — |

*The General Management of the Rumanian Railways* has furnished the following data :

On lines with little traffic, benzine rail motor coaches with electric transmission of 60 to 90 H. P., are used, these vehicles having been built in 1905-1912.

Tests with rail motor coaches were carried out in 1903; for this purpose in addition to steam rail motor coaches, benzine rail motor coaches with mechanical transmission were used. In 1905, 22 benzine rail motor coaches having a power of 40 H.P. with electric drive were purchased, but these rail motor coaches proved themselves too weak to meet traffic requirements, and they were taken out of service in 1912, whilst the others were fitted with more powerful motors. These vehicles have four wheels (fig 9).

At the present time it is intended to purchase Diesel-electric rail motor coaches of 120 to 200 H. P., the operation of which costs less and is more economical and which better meets the needs of regularity in operation.

The average number of trains running over the lines operated with rail motor coaches varies between 2 and 8 per day, which is equal to a total of 32 or 288 train-km. (20 or 179 train-miles). On the

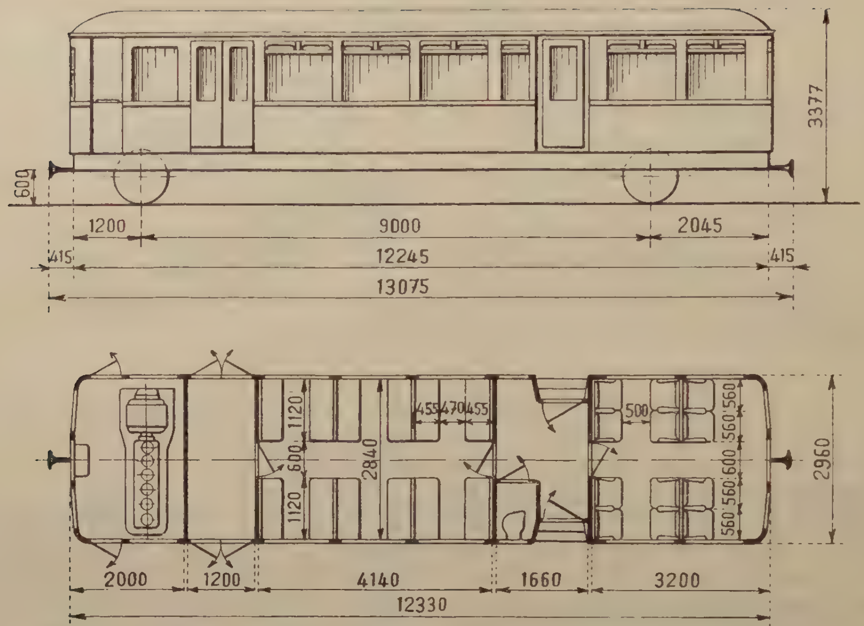


Fig. 9. — Rumanian Railways. — Benzine rail motor coach.

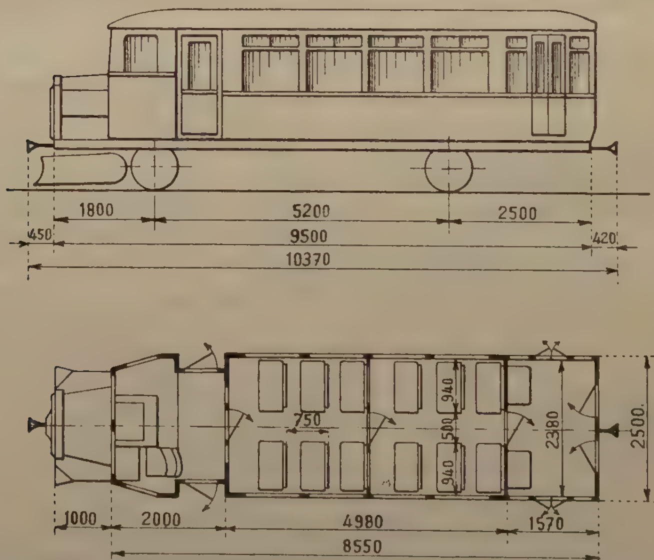


Fig. 10. — Norwegian State Railways. — Benzine rail motor coach.

lines with mixed workings (steam locomotives and rail motor vehicles) the average number of trains is 28 per day or 2 570 train-km. (1 597 train-miles).

10 of these rail motor coaches are in service daily. Their maximum speed is 65 km. (40.4 miles) per hour.

The rail motor coaches are driven by a driver with an assistant; in addition, the necessary train staff is on the train.

The staff on lines with little traffic are under the same conditions of service as those on the main line. The period of work is 9 hours per day, the period of rest can be reduced from 15 to 8 hours if the requirements of the service make it necessary.

The rail motor coaches are stabled in special sheds.

The average consumption of combustibles for these vehicles according to the power of the motors, is from 585 to 715 gr. per km. (2.07 to 2.54 lb. per mile). The annual distance run amounts to 50 000 km. (31 000 miles) in round figures.

*The General Management of the Norwegian State Railways,* has sent the following information :

For the small trains use is made of light locomotives built many years ago and driven by a single man. During recent years operating by means of benzine rail motor coaches has been introduced. At the present time two vehicles of this type having 4 pairs of wheels and 13 of 2 pairs are in use; 8 more four wheeled rail motor coaches should be put into operation shortly.

The motors of eight wheeled vehicles have 6 cylinders and develop a power of 160 H.P.; the power is transmitted mechanically.

The motors of the eight wheeled vehicles have also 6 cylinders and a H. P. of 75 and 110 respectively.

Their maximum speed is fixed at 55 km. (34 miles) per hour.

The weight of the rail motor coaches varies between 10 and 25 tons; the number of seats is from 40 to 100 (fig. 10).

Single man driving has been introduced; with this object the rail motor coaches are fitted with a safety device by means of which the train is stopped should the driver be taken ill. A conductor is provided when the trains have a trailer attached.

The conditions of service of the staff are the same on all the lines, without respect to their importance. The weekly period of work does not exceed 48 hours; the time on duty should if possible, not exceed 12 hours, and the minimum period of rest not be less than 9 hours. The make up of the train consists according to the type of motor, either of a rail motor coach alone, or a rail motor coach with a passenger trailer and possibly if need be a goods wagon, so that the weight of the train can reach 32 tons. In the event of heavy traffic, instead of the rail motor coaches more powerful steam locomotives are made use of.

The benzine rail motor coaches are stabled in the locomotive depots, provided there is no locomotive under steam therein; there are also special sheds intended for stabling rail motor coaches.

The handling of the locomotives and their maintenance are in the hands of a specially trained staff, who as a rule are drivers or locomotive firemen having received suitable training.

The costs based on the year 1928, on an average amount to 0.158 gold-franc for fuel, and 0.015 gold-franc for lubricating materials per train-kilometre (respecti-

vely 0.254 and 0.024 gold-fr. per train-mile).

The purchase price of the rail motor coaches is from 99 000 to 111 000 gold-francs according to the type.

The distance run by these machines varies between 30 000 and 50 000 km. (18 600 and 31 000 miles) according to type.

Seeing that we are still in the experimental stage as regards operating the lines with rail motor coaches it is not possible to supply any definite information at present; the tests are being continued.

CONCLUSIONS.

The information given above has enabled the following *conclusions* to be made:

1. The efficiency of steam locomotives, and other steam rail motor vehicles is not satisfactory for the service of lines with little traffic. Special locomotives built for such working will continue to be used so long as they remain in existence; on the other hand it is not intended to build any more.

2. On most railway undertakings experiments have been carried out with rail motor coaches fitted with internal combustion motors, or are being made at the present time. Experiments are also being made with benzine rail motor coaches and Diesel motor coaches, the power being transmitted either mechanically or electrically, the latter being the more modern method.

3. From the data supplied it appears that the Diesel electric rail motor coach offers the greatest advantages owing to its cheap cost of operation and to the fact that it can stand a certain overloading.

4. On electrified lines with overhead equipment the use of electric rail motor vehicles alone can be considered.

5. The possibility of using one man to drive these vehicles results in important savings, both in the case of benzine rail motor coaches as with Diesel rail motor coaches or other electric motor vehicles.

6. The question of the use of rail motor coaches of special construction for working lines with little traffic is still under consideration; it is not yet possible to give any final judgment as to the type of vehicle to be selected. The tests undertaken with internal combustion motor vehicles should be extended as much as possible.

* * *

B. — **The use of special tractors for shunting in smaller yards and for certain work in large yards.**

*The Netherlands State Railway Company and the Dutch Railway Company* report as follows:

At the present moment there is only one benzine tractor in use; definite results as to the economic advantages to be obtained with this machine are not yet available.

*The Management of the Royal Swedish State Railways* states :

Tests with benzine tractors have been carried out for some time; no information can yet be supplied as to the results obtained.

*The General Management of the Danish State Railways* reports as follows:

For shunting, in addition to horses, there are benzine tractors fitted with

capstans. Whereas the horses cannot haul more than two wagons weighing about 50 tons, with the tractors a weight of approximateley 200 tons can be hauled.

The maximum speed of these vehicles is 25 km. (15.5 miles) per hour; they are worked by the usual staff which has been instructed for the purpose.

The tractors have been in use since 1925; they have shown appreciable savings. Their purchase has had the effect of suppressing in some stations shunting by means of locomotives and has accelerated the movement of the rolling stock. The tractors are used as a rule in conjunction with steam shunting engines.

*The Ministry of Railways of the Czecko-Slovakian Republic* supplied the following information regarding the *State Railways:*

Up to the present no special vehicles have been used for shunting purposes, but it is intended to carry out tests with tractors. These latter will have benzine motors with electric drive.

*The General Management of the Swiss Federal Railways* has sent the following information:

The vehicles shown in the table below are in use for shunting at stations:

| Number. | Kind of vehicle. | Tractive effort in kilogrammes (in pounds). | Load in tons. | Working speed in km. (in miles) per hour. |
|---|---|---|---|---|
| 1 | Electric tractor . . . . . . . . . . . . . | — | 2-3 wagons | 16 (10) |
| 2 | Electric locotractors . . . . . . . . . . | 6 000 (13 230) | 250 | 30 (18.6) |
| 16 | Accumulator tractors . . . . . . . . . . | 2 000 (4 409) | 150-300 | 10-45 (6.2 to 28) |
| 1 | Benzine locomotives . . . . . . . . . . | 5 500 (12 125) | 250 | 3.5 to 15 (2.2 to 9.3) |
| 20 | Benzine locomotors . . . . . . . . . . | 700 and 2 000 (1540and4490) | 180-325 | 3 to 15 (1.9 to 9.3) |
| 2 | Single axle accumulator tractors running along-side the track . . . . . . . . . . . . | 250 and 750 (551 and 1 653) | 100 | 3.5 (2.2) |
| 5 | Electric « Spills » . . . . . . . . . . . . . | — | 1-2 wagons | — |
| Var. | Motor tractors . . . . . . . . . . . . | — | 40-45 | 3 to 4.5 (1.9 to 2.8) |

The benzine locomotives are fitted with a lifting device which acts under the head stock of the wagon and thereby carries part of the weight of the vehicle. It is intended to purchase more of these benzine locomotives, as with them it is possible to carry out all shunting operations in the stations. On the other hand in view of the high cost of repairs and the necessity to have charging stations it has been decided not to purchase any further accumulator motors.

As a rule satisfactory results have been obtained with all the vehicles given in the above table; the time goods trains stand in the stations and the yards equip-

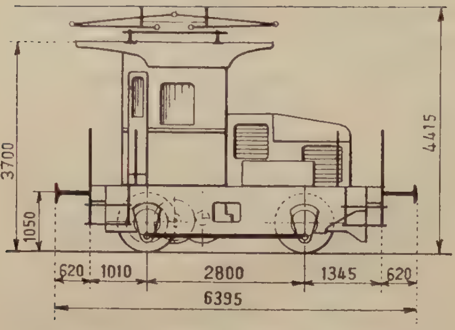


Fig. 11. — Swiss Federal Railways. Electric locotractor.

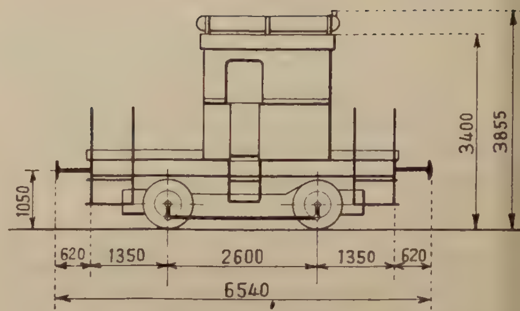


Fig. 12. — Swiss Federal Railways. Rhætian Railways. — Benzine locomotive.

ped with such machines has been shortened and by their use delays to trains have been reduced or even avoided.

These machines are worked by a man in the goods department or belonging to the station. The costs are as follows:

| Kind of vehicle. | Consumption. | Maintenance. | Cost price. | Period over which vehicle is depreciated, in years. |
|---|---|---|---|---|
| | ← Gold-francs. | | → | |
| Electric tractor | — | — | — | — |
| Electric locotractors | — | — | 102 000 | — |
| Accumulator vehicles | 1.80 | 9000 | 106 000 | 12 |
| Benzine locomotives | 7.—,9.— | — | 47 800 | — |
| Benzine locomotors | 1.50 | 700 | 14 000 | 10 |
| Single axle tractors | 0.90 | 800 | 10 400 | 12 |
| Motor tractors | 2.00 | — | 3 000 | — |

Where no figure is given the necessary information cannot be obtained.

*The Rhœtian Railway Management* reports as follows :

In order to carry out the shunting operations in the stations a benzine locomotive is used which weighs 20 tons with a motor of 100 H. P.

The speed is 26 km. (16.2 miles) at the maximum, and its maximum tractive power is 2 860 kgr. (6 305 lb.) (fig. 12).

This locomotive is employed on shunting 8-10 hours each day; it is worked by a driver with a brakesman. It has been in use since 1927 and has shown definite advantages from the fact that it can be used anywhere and can be very quickly got ready for service.

The information given by the *General Management of the Rumanian Railways* is as follows:

Steam locomotives only are used for shunting in stations. The repair shops in addition have a benzine tractor which is also used for shunting purpose and in particular for dealing with wagons for repairs. The power of the motor tractor is 40 H.P. It can haul 150 to 200 tons and the speed is 10 km. (6.2 miles) per hour. These tractors which are worked by a workman give every satisfaction.

*The General Management of the Norwegian State Railways* has supplied the following information:

For carrying out shunting in the stations two locotractors with benzine motors and a benzine locomotive have been put into service for test purposes.

The locotractors have 35 H.P. motors and their speed is 18 km. (11.2 miles) per hour at the maximum. They are used for shunting goods wagons and have made it possible to shorten the time the trains stand at stations.

The benzine locomotive has a 52-H. P. motor; its tractive power is 1 100 kgr. (2 425 lb.) and its maximum speed is 16 km. (10 miles) per hour.

The vehicles are driven by a station employee.

In addition to these two types of vehicles two accumulator locomotives are still in use and are used for shunting electric locomotives on arrival and leaving the shed.

*The Bergslagen Railway Management* replies as follows :

For shunting in the shops and stores a benzine locotractor is used capable of hauling 4 wagons on the level. The adhesive weight of the tractor can be increased by taking part of the weight of the wagon. The consumption of combustible is, for this tractor, 500 to 600 grammes (1.10 to 1.32 lb.) of benzine per hour of shunting.

## CONCLUSIONS.

From the above information, the following conclusions can be drawn :

For economical shunting in large stations and yards it is desirable to use special machines, such as benzine locomotives and locomotors. Where there exists an overhead electric line electric tractors can be used advantageously. Accumulator vehicles are only used exceptionally in view of their high cost of maintenance and the need for providing charging stations.

[ 656 .1 & 656 .2 ]

# REPORT No. 4

**(All countries except America, the British Empire, China, Japan, Belgium, France, Italy, Portugal, Spain and their Colonies)**

## ON THE QUESTION OF COMPETITION OF ROAD TRANSPORT (SUBJECT XIII FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION (1) (2),

By Dr Alexandre WASIUTYŃSKI,

ENGINEER OF THE LINES OF COMMUNICATION, PRESIDENT OF THE COMMISSION ON THE RECONSTRUCTION OF THE RAILWAY TERMINI IN WARSAW.

## SUMMARY :



### I. — Foreword.

The subject of question XIII of the eleventh Session of the Madrid Congress was stated in the programme of the session as follows : « Effect of road competition on goods and passenger traffic, and the best methods of meeting such competition, both as regards the main lines and the branches. »

A detailed questionnaire relating to this question, and drawn up in agreement with the other reporters, was sent to the Member Railway Administrations of all countries with the exception of those enumerated at the head of this report.

The replies received from the Administrations, to the number of 15 belonging to 10 countries, are given in the appendix. The replies to the first four points of the questionnaire, mainly in the form of figures, are given in a common table with several deductions regarding the annual increase in the numbers of motor vehicles, as well as the number of inhabitants per vehicle. The replies to the following points of the questionnaire are examined separately under each point.

### II. — Summary of the replies.

(See appendix.)

(1) This question runs as follows : « Competition of road transport. Effect of road competition on goods and passenger traffic and the best methods of meeting such competition both as regards the main lines and the branches. »

(2) Translated from the French.

## III. — Analysis of the replies.

### 1. Importance of motor transport in the country.

The number of motor vehicles in relation to the population of the countries examined varies within wide limits. The number of inhabitants per motor lorry is 223 to 231 in Denmark and Sweden, 310 to 362 in Norway and Switzerland, 559 in Finland, and exceeds 1 000 in the other countries. The number of inhabitants per motor bus and motor coach is 2 320 to 2 740 in Norway and Finland, 3 320 to 3 770 in Sweden and Denmark, 4 860 to 10 400 in Switzerland and Poland, and amounts to tens of thousands in other countries. The number of inhabitants per private motor car is less than a hundred in Denmark, Sweden, and Switzerland, between 133 and 208 in Norway and Finland, and is much greater in the other countries.

The number of inhabitants per motor vehicle of all kinds approaches in Denmark that of France, and in Finland that of Germany. It keeps within these two figures in the other European countries in question, excepting in Poland and Czechoslovakia, where it is much greater.

The average increase in the number of motor vehicles is very variable. For most of the countries it is 20 to 30 %, in others, like Switzerland and part of Sweden, it is much less, while in others, like Finland, it is twice as great.

This increase corresponds to that of the other European countries, and its variations are to be attributed to variations in price and to other local circumstances.

### 2. Regular motor services in the zone covered by the railway system.

The density of regular motor services varies for the European countries in question from 5.5 km. per 100 km$^2$ in Norway to 32.9 km. in Denmark. In most of the countries, the average length of a service is about 30 km. (18.6 miles). It is 41 km. (25.5 miles) in Poland and only 11 km. (6.8 miles) in Switzerland.

### 3. Competitive motor services.

The length of the motor services in proportion to that of the railway system is 21.3 % in Denmark, and 85 % in Poland. It is stated to be very great in Sweden, while in other countries it is small, which may be partly due to the extensive character of the road transport system (Finland, Norway), and partly to the thorough control to which the motor services are subjected (Switzerland).

### 4. Traffic of the competitive motor services.

There are no figures to show the extent of the goods traffic of competitive road transport, and there are practically none as regards the passenger traffic. In Norway and Poland the distance travelled by motor bus passengers is about 5 % of the distance travelled by railway passengers.

### 5. Control of competitive motor services.

#### a) *Official authorisation.*

With the exception of Greece and the Dutch East Indies, where motor traffic is not subjected to any special legislation, the operation of the regular motor services in all the other countries requires the authorisation (licence, concession) of the administrative authorities. This permission is usually granted by the local administrative body of the district, which takes into consideration the interests of

existing means of communication. In Denmark the permission of the local administrative body has to be confirmed by the Minister of Public Works. In Norway and Switzerland it is the central authority (Bridges and Roads Department, Post and Railway Department) which grants the licence on the recommendation of the local authorities.

In Switzerland the concerns which have obtained a concession are subject to the laws governing the civil responsibility of railway companies, as well as to the laws regulating the hours of work, and are obliged to insure their employees. A concession is usually granted for 10 years. In Poland the licence is only granted for 1 year. It is not known how long the licence is valid in other countries. The replies of some countries (Denmark, Poland, and Switzerland) state that the preparatory work relating to the statutory control of motor traffic, or to alterations in the present laws, is in progress.

b) *General plan.*

A general plan for regular motor services conceived with the object of providing for the needs of the public, does not exist in any country except, perhaps, in the case of the Sumatra system in the Dutch East Indies, where all these services belong to the State Railways. The concessionaires are at liberty to select the routes they wish to serve but, with rare exceptions, when their applications for licences are considered the necessity for the services and the means of communication already in existence are examined, and fresh licences are not granted in districts where the service is already ample.

In Switzerland the authorized services ply in districts which the railway does not reach, and thus form a useful adjunct to the railway system. No concession is granted to motor services which would seriously compete with the railway.

c) *Subsidies.*

The regular motor services are not subsidised by the public authorities except in Norway in the districts which are least populated and least provided with means of communication, as well as in certain of the Swiss cantons; in Switzerland the subsidies generally take the form of a repayment by the public authorities of part of the working losses.

d) *Share in the cost of road maintenance.*

In most countries, principally Denmark, Norway, Holland, the Dutch East Indies (Java), Sweden, and Czechoslovakia the regular motor services contribute to the cost of maintaining the roads by paying taxes, the revenue from which is used for this purpose. In Holland and in the Dutch colony of Java these taxes are also intended to cover the expenses of making roads. The taxes are levied on the motor vehicles in proportion to their weight (sometimes in proportion to their weight and the distance covered), on the tyres, and on petrol. In Finland the regular motor services contribute to the upkeep expenses of the roads only when they use communal roads. In the Dutch East Indies (Sumatra), Poland, and Switzerland, the regular motor services only rarely contribute to the upkeep expenses of the roads, and then only to a small extent, while in Greece they make no contribution whatever.

The railways (belonging, as regards most of the countries in question, to the State) bear all the expenses of upkeep

and reconstruction of their equipment and installations, but are exempt from special taxes.

e) *Fixing the transport rates.*

In Denmark, Finland, and Norway, the passenger and goods rates by regular motor services, and in Holland, Switzerland, and Czechoslovakia the passenger rates only, are fixed by the authorities granting the authorisation (licence, concession). In Sweden the authorities fix a maximum for the passenger and goods rates. In Greece and Poland the operators are free to fix the rates on their services.

f) *Monopoly or open competition.*

In none of the countries do the concessions (licences, authorisation) of the regular motor services bear the character of monopolies. But, while reserving the right to grant concessions to other services on the same route, every effort is made to avoid unfair competition. It is only in Greece and Poland that competition is left absolutely open.

g) *Preferences in obtaining a concession.*

In none of the countries where competition is not left entirely open, does there exist any undertaking enjoying the right of preference in obtaining the concession to run regular motor services. It is noted that in Switzerland, the State undertakings and large private undertakings usually obtain the preference owing to the better financial guarantees they offer.

**6. Rates of motor services.**

In no country are there in existence any definite rules fixing the transport rates of the regular motor services, and these prices vary, according to the circumstances within wide limits. In some countries (Denmark, Norway, Sweden) the average prices for the transport of passengers by road amount to about 14 gold-centimes (22.5 gold-c. per mile) while in others (Poland, Yugoslavia, Czechoslovakia) they are about half this. Since the prices of passenger transport by rail differ less in different countries, amounting to 6 to 8 gold-centimes per km. (9.6 to 12.9 gold-c. per mile) for the 3rd class, it follows that the prices of transport by regular motor services are 10 to 100 % higher than 3rd class prices on railways.

Few figures of the transport rates for goods by motor services are available. The prices of transport by motor are : Norway, 0.83 gold-fr. per tonne-kilometre (1.36 gold-fr. per Engl. ton-mile) (by rail 11 to 12.5 gold-centimes [0.18 to 0.20 gold-fr. per Engl. ton-mile]), Sweden, 0.70 to 1.11 gold-fr. (1.14 to 1.63 gold-fr. per Engl. ton-mile), Switzerland, 0.90 to 1.20 gold-fr. (1.47 to 1.96 gold-fr. per Engl. ton-mile), Dutch East Indies (Java), 0.30 to 0.60 gold-fr. (0.49 to 0.98 gold-fr. per Engl. ton-mile). The statement that in Switzerland the price of transport of goods is 15 to 20 % less by road than by rail appears to be an error.

**7 and 8. Effects of the competition of regular motor services and of motor traffic in general.**

The Administrations state that the competition of road transport is affecting the traffic on their lines, but they experience difficulties in making a distinction between the influence of regular motor services and that of the other modes of motor transport.

The Federal Swiss Railways state that

the competition of the few adjacent motor services is in their case insignificant as regards both passenger and goods traffic. The Rhætian Railway in Switzerland states that, thanks to the laws in force, there is, so far, no fear of any considerable competition from motor transport.

In Poland, the passenger traffic of the motor services in terms of passenger-kilometres amounts to 5.5 % of the corresponding traffic of the competing railways, and their loss does not exceed this limit. The annual loss in revenue from passenger traffic owing to the competition of the whole of the motor traffic is estimated at about 8 % in Switzerland, Czechoslovakia and the Dutch East Indies (Sumatra), and about 12.5 % in Norway. According to the statistics of the Netherlands State Railway Company the receipts from passenger traffic increased on an average by about 13 % annually for the years 1917 to 1921, and decreased by about 4 % for the five years following. It would follow that the annual loss of this traffic for the Dutch railways amounts to 17 %.

In Sweden several light railways have since 1913 suffered a decrease of 20 to 40 % in passenger traffic, undoubtedly due to motor transport. The State railways of Finland, Sweden, Czechoslovakia, and Yugoslavia state that there is a falling off of passenger traffic as regards short distance traffic only, while the total passenger traffic is on the increase. The State Railways of Denmark and Greece declare that they possess no information in reply to this question.

The losses in goods traffic caused by road competition is estimated in Norway at 6.85 %, and in Switzerland at 10 % of the receipts. The Swedish State Railways remark that it is only the short distance traffic which is decreasing, while the total goods traffic has increased considerably. The Swiss Federal Railways estimate their losses in goods traffic at about 10 % of the receipts from this traffic, stating that the competition of regular motor services for this traffic is unimportant, and that most of the traffic taken from the railways has been through business houses or industrial firms carrying on their own account or on account of third parties, as well as by carriers satisfying the needs of their clients. The same state of affairs obtains in Holland, as will be seen from the reply furnished by the Netherlands Railway Company.

There is no information regarding road competition for goods traffic in other countries.

**9. Improvement of rail transport to meet the competition of motor transport.**

The replies to the questionnaire indicate among the causes deciding passengers and consignors to use motor transport in preference to rail transport, the lack of flexibility of the railway, meaning that transport by rail cannot be carried out in any direction but in one definite direction only, which does not always correspond to the requirements of the passengers or consignors. This defect, being inherent to railways, cannot be avoided, and the same applies to the position of the stations, sometimes situated at more or less considerable distances from the centres of habitation, and to the impossibility of stopping at any place at the desire of the passenger or consignor. It is only possible to palliate these defects by using additional means of transport involving transhipment in order to complete the transport.

In this connexion the above-mentioned defects emphasize *the lack of arrangements for effecting complete transport from house to house*.

In addition, the replies to the questionnaire indicate the following as causes for the preference accorded to motor transport in passenger traffic : insufficient frequency and slowness of trains, lack of attention paid to the interests of small localities in drawing up the time-tables, inconvenient connexions with branch lines, and lack of comfort in 3rd class coaches; and in goods traffic (apart from the *ad valorum* charges, vide N° 10) lack of cartage at the less important stations, slowness of the transport, especially over short distances, and the formalities to be gone through prior to despatch.

The measures which have been adopted to remedy these defects in *passenger traffic* include in the first place improvements in the time-table, principally in speeding up the trains and increasing their number. The electrification of some lines has materially assisted in attaining this object.

The organisation of local services of light and frequent trains, in the form of rail motor coaches and rail motor cars, on lines where traffic is not heavy, with frequent stops between stations, is a measure adopted almost universally. In Czechoslovakia, rail motor coaches have given particularly good results by reducing the duration of journeys, by simplifying the service, and by reducing the working expenses. A 7-ton rail motor coach containing 30 seats and standing room, pulling a 5-ton coach with the same number of seats and a compartment for luggage and parcels forms a train which answers the requirements of local passenger traffic much better than the mixed trains of former days. These rail motor coaches, the average speed of which reaches 50 km. (31 miles) per hour can compete successfully with road motor buses as regards both speed and comfort, and the passenger traffic has gone up considerably since they were put into service.

Improvements in the connexions between trains at junction stations, the organisation of through trains on branch lines, as well as the reduction in the number of mixed trains and the introduction of special trains at reduced fares on holidays , have been applied successfully.

In Denmark, the seats in 3rd class coaches are gradually being upholstered.

*As regards goods traffic*, the trains have been speeded up, and reforms have been made in the despatching of goods and in the organisation of motor lorry transport for the house to house collection and delivery of goods.

The traffic has been speeded up by means of through goods trains, by attaching in some cases full wagons to passenger trains, by improving the time-tables so as to reduce the duration of journeys and stops in stations, and by a more prompt despatching of goods from re-loading stations.

On the main Swiss lines the despatch of individual parcels is effected twice daily in each direction. Night work or work before and after the usual hours has been introduced in the goods stations attached to the large stations, and the opening times of booking offices have been extended.

In Czechoslovakia definite arrangements have been made to deal with the

regular consigments of goods from certain particular firms.

The introduction or the reorganisation of cartage either by railway-owned lorries or in collaboration with contractors is being carried out on some railways. In Switzerland a cartage service operated by the railway staff has been established in the small and moderate sized stations.

A very interesting undertaking of the Swiss Federal Railways was the establishment in 1926 of a Company, the « SESA », which is solely concerned with the relationship between road and rail transport, and intervenes in favour of the railway by supervising the effect of competition and maintaining it within certain limits. This Company has improved, amplified, and cheapened the cartage collection and delivery service. In the same way it has organised motor services to extend and improve the transport between localities not served by the railway. According to the Administration of the Swiss Federal Railways the activities of the « SESA », which has already brought back to the railways a considerable amount of traffic that had passed into the hands of motor transport, are continually increasing and are giving satisfactory results.

### 10. Tariff measures to meet motor competition.

The revision and reduction of transport rates, with the object of diminishing the effect of motor transport competition, have been carried out in recent years by almost all the railway systems, with the exception of the State Railways of Finland, Greece, and Poland, where it is considered that the reduction of the railway rates would not be of any advantage to the railway in meeting motor transport, which is extending by virtue of other advantages.

The changes in the rates have been made in the form of a reduction in the passenger and parcel charges for short distances up to 100 km. (62 miles) (Norway, Sweden), or only in certain instances (Czechoslovakia, Dutch Indies). In Denmark, Holland, Switzerland, and Czechoslovakia, the railway administrations have been authorised in special cases to conclude agreements with their clients regarding transport charges.

In Switzerland, the railways decided on 1 April 1927 to transport goods by express and slow trains, at charges including cartage, corresponding to the costs of transport by motor lorries, provided that the consignor can show that, without this concession, it would be more profitable for him to send goods by motor lorries, that he is in a position to do so, and provided that he undertakes to send a certain minimum of goods annually by rail and foregoes the use of motor lorries. The « SESA » (see No. 9) is empowered to make the necessary negociations with the consignors.

### 11. Other measures against motor competition.

The lack of improvement in rail transport and the disadvantages of the scale of charges are far from being the principal causes of the success of motor competition.

Considering first of all the competition of the regular motor services only, the replies show that the statutory control of these services, even in the countries that are most up-to-date in this respect, is not yet complete and that in many others it

is merely in the preparatory stage (see above, No. 5*a*). There is still a general failure to recognise the fundamental idea that the operation of regular motor transport services should not be regarded as a trade which is open to all, that their importance demands that they should be co-ordinated in the public interest with the other means of transport, and that the competition of these services among themselves, and with the railways, ought to be kept by statute within the recognised proper limits. Nevertheless, the replies to the questionnaire indicate that efforts are being made to have this principle embodied in the new statutes, which is indispensable if regrettable competition is to be avoided.

In Norway an official commission, appointed to study the question of road competition has come to the conclusion that, in regions provided with railways, permission to run regular motor services should not be granted except when such services would constitute a natural extension of the system of communications or when they would supplement the railway in such a way that the activities of the railway and the motor service would complete each other. This desideratum, however, has not yet been given legal force.

In other countries where the regular motor services are the object of concessions or licences, the authorities granting them are usually expected to take into consideration the interests of existing means of communication. It appears, however, that the regulations in force do not sufficiently prevent the authorisation of regular motor services in competition with the railways, since in some countries, such services exist in large numbers. It is only in Switzerland (see No. 5-*b* above) that the regulations in force « enable the authorities to refuse to grant a concession for motor services which would constitute a serious competition with the railways, and that those services in existence complete, in a useful manner, the railway system ».

The replies prove, however, that the losses caused to the railways by the competition of regular motor services are relatively small in comparison with the losses due to the competition of private cars. The administration of the Danish State Railways remarks that the very large number of motor cars in private use in the country has helped materially to reduce the use of railways by well-to-do people, and that it is scarcely possible to take any effective measures against this reduction in traffic.

As regards the causes of the competition of private motor lorries, the Swiss Federal Railways give a detailed list (see Appendix, question 11) of the profits and advantages resulting to themselves and their clients, from the direct and rapid delivery of goods by the suppliers' motor lorries, as well as of the privileges of motor transport compared with the charges which fall upon the railways, namely : obligation to carry goods, legal liability, regulation of hours of work of employees, stamp duty, and constructional and maintenance expenses.

The unequal treatment of the motor services and the railways, as a result of the law, is to be attributed to the newness of motor traffic and to the consequent absence of statutes relating thereto. Projected reforms, with the object of filling this gap to some extent, have been referred to by the railway administrations. It is interesting to note that on the occasion of a motion of the Administra-

tive Council of the Swiss Federal Railways, intended to protect the Swiss railways against road competition, the Federal Council explained the manner in which they intend to carry this out. In the opinion of the Swiss Government, the motor traffic and the rail traffic should be put on approximately the same footing from the legal standpoint. It would be a question not merely of the statutory control of the obligations of the motor traffic, but also the mitigation of some of the fundamental obligations of the railway, such as the obligation to provide transport, and the strict observance of the rates.

The measures taken by railways to ensure the direct and rapid transport of goods have been discussed in N° 9 above. It is evident, however, that they can only partly meet the irregular service of privately-owned motor lorries, which, in some instances, will always have its advantages.

The public have become accustomed to travel independently, and to take advantage of direct offers. The railways ought to adapt themselves to the new traffic conditions, and advertise their services skilfully. The Danish State Railways have for this purpose established contact between their clients and specially appointed employees which is carefully followed up. The Swiss Federal Railways, in the small stations, have interested their employees in the cartage service. The East Seeland Railway is right in including among the means for meeting motor competition, in addition to the rapidity of transport and the regularity of despatch, the obliging and serviceable attitude of the railway employees.

Finally, the necessity for and the good results of adequate publicity on the part of the railways to inform the public and react against the competition of motor transport, which is frequently a result of fashion,are often mentioned in the replies of the administrations to the questionnaire.

### 12. Regular motor transport services as an auxiliary undertaking of railways.

Almost all the railway administrations who have replied to the questionnaire, have organised regular motor services as an auxiliary undertaking.

The Danish East Seeland Railway, the State Railways of Norway, Sweden, and Czechoslovakia operate these services themselves. The Stockholm-Roslagen Railway in Sweden has taken over all the competing motor bus services. The State Railways of the Dutch East Indies, the Sumatra system, themselves operate all the regulator motor services of that country, extending to a length of 1 552 km. (964 miles). The State Railways of Greece and Poland state that the organisation of the regular motor services as an auxiliary undertaking to their administration is in the preliminary stage.

The administrations of the Netherlands Railways and of the Swiss Federal Railways have entrusted the operation of their regular motor services, as well as the motor lorry transport and the business connected thereto, to limited liability companies, which they have organised as independent undertakings by supplying the necessary capital.

The regular motor services operated at the present time as ancillary undertakings to the railways are mostly services which are connected wich the railways as feeder lines; there are however some which connect by a shorter route

localities connected by railways, and some which run parallel to the railway to relieve heavy traffic or to supply the place of a railway originally planned. Although in many instances the undertakings are of recent formation and consequently no opinion of their working can be expressed the general opinion of the administrations on the results of their operation is favorable, and the intention of developing them is pointed out.

### 13. Mixed service of through transport.

The agreements concluded with the concessionnaires of the regular motor services have enabled the Norwegian and Swedish State Railways to despatch and transport goods directly by rail and certain motor services in both directions. A scale of charges has been drawn up on the Swiss Federal Railways for the through carriage of luggage and express parcels between the railway stations and the stations of the motor services operated by the Post Office. On the Dutch East Indies Railways, Java system, the mixed through transport is organised into goods traffic and passenger traffic On the Sumatra system, the organisation of a similar service was facilitated by the fact that all the regular motor services in that country are run by the railways. A mixed service of through transport has been planned by the administrations of the State Railways of Poland and Czecho-Slovakia.

### 14. Other means of developing motor services as feeders.

The replies of the administrations do not state that other means of developing motor services as feeders (for example, the use of containers) are in use on their railways.

## IV. Notes on the road competition in other countries according to published statements.

### 1. The World Motor transport Congress and the motor competition in the United States of America and in France.

At the London Session of the World Motor Transport Congress, 1927 (1), a number of papers on the development of this transport, its relationship with rail transport, and the necessity for cooperation between road transport and rail transport were read and discussed. The communications of the French and American engineers at this Congress deserve special attention.

*In the United States* the number of motor vehicles in 1927 attained 1 per 5 inhabitants. During the past six years the trunk lines have lost 25 % of their passenger traffic and 25 % of their higher rated goods traffic in part wagon loads. The roads were crowded while the pasenger trains were running empty. M. Bacon, of the New York, New-Haven and Hartford Railroad, gives a description of the steps which the administration of this railway took to meet the road competition, which had reduced by 40 % the number of passengers. entirely short distances, and its receipts by 28 million dollars annually, of which 3.3 millions, or about 12 %, passed to the motor bus services. This railway system serves a rectangle of about 400 by 160 km. (248.5 × 99.4 miles) with its south west corner touching New York. In the initial period of keen competition, the railway company was obliged to re-

(1) World Motor Transport Congress, London 1927. Complete Report of Proceedings.

duce its services owing to the reduction in passenger traffic. Small companies, sometimes individuals of no standing, operated regular motor services, took the cream of the local traffic, paying little heed to the through passenger traffic and the maximum fluctuations of goods traffic. The New York, New-Haven and Hartford Railroad decided not to abandon any section of its lines however small the revenue, before making every effort to reduce its working expenses. Two methods were used for this object. The first was the use of petrol rail motor coaches (gasoline and electrical transmission) in place of steam locomotives. By this means it was possible to continue operating branch lines with little traffic, by reducing the costs by half. The second means, possessing great flexibility, was the motor bus. The Company formed the « New England Transport Company » the object of which was to organise regular motor services and, in cooperation with the railway, to carry out all the necessary improvements to provide passengers with all the comforts of a complete and through journey. In two years, since 1925, 191 motor buses were put into service on a distance of 2 000 km. (1243 miles) which carry 4 500 000 passengers annually. The regular motor services were organised as feeders or parallel to the railway in order to improve the railway time-table, or to replace the rail motor coaches in case of very heavy goods traffic and very slack passenger traffic, as well as in other instances where they could help to regain the traffic which the railway was losing. It often happens that the three means of transport : by steam locomotive, by rail motor coaches, and by motor bus are being operated in the same directions. Agreements have been made with some motor transport companies, and the rights of others have been bought. Interchangeable tickets are sold for a journey by rail or by road, as well as through tickets for a combined journey by both.

Experience has proved that, on the Boston and New York line, which has a daily service of 20 express trains making the journey in 5 or 6 hours, some passengers prefer to travel by bus although it takes twice as long.

As regards goods traffic, the public is indifferent to the means of transport used, provided that the result, namely : safety, rapidity and economy of transport, is satisfactory. In passenger traffic, however, the comfort of the journey is more important than the price. Besides, it is the fashion and there is the attraction of novelty. If the railways would pay more attention to the tastes of the public, and try to offer them interesting and well-arranged routes, they could expect to win back many of their old clients who have become dissatisfied by the crowded roads.

What the railways ought chiefly to consider, however, is that it is their duty to offer the public *complete transport*. This is what should be understood by the cooperation of the various means of transport and the necessity for co-ordinating them. In the United States, the railways are not generally opposed to motor transport, but are rather against isolated efforts, wich deprive them of traffic, and which are even prejudicial to most of the independent motor transport undertakings.

By applying the methods outlined above, the New York, New-Haven and Hartford Railroad has regained in many cases more passengers than it had lost. A well organised motor service has shown

itself to be advantageous both to the public and to the Railway Company.

*In France* the taxes and other charges borne by the railways are much heavier than those of the regular motor services, which puts them in unequal conditions and facilitates the competition of motor transport. But, as was pointed out by M. Loiret, Chief Inspector of Mines, representing the Minister of Public Works at the London Session of the World Motor Transport Congress, the fact remains that the cases where the motor and rail may assist each other are more numerous than those where they are rivals. The French railways have not only shown little fear in face of the development of the new system of transport, but they have largely adopted it. Furthermore two-thirds of the regular motor services are subsidised by the State, the Departments or the Communes. French legislation, while leaving a wide latitude to private undertakings, holds under its control, especially as regards the time-tables and the rates, those occupied with transport, and the State possesses the means of dealing with any opposition if public interests demand it.

The question of co-operation between road transport and rail transport was again raised at the Rome Session of the World Motor Transport Congress in 1928, and was the subject of a very interesting paper by M. Pourcel, Chief Engineer of the Paris, Lyons and Mediterranean Railway. In this paper M. Pourcel compares the two modes of transport, motor and rail, defines their scope, and indicates as the solution of the extensive and complex problem of their co-operation, and one promising the best results, that selected in France, namely : the organisation by the principal railways of ancillary motor transport companies. M. Pourcel compares the two modes of transport, giving their principal differences : the road of ten times greater extent than that of the railways, forming a capillary system, of which each inhabitant feels himself to be a branch, and the tractive power, infinitely smaller than that of rail locomotives. The nature of its roadway, makes the motor a very valuable cooperator with the railway, but at the same time a rival, with the advantage of door to door transport.

Estimating the cost of transport by motor lorry to be half that of horse-drawn transport and ten times that of transport by goods train, M. Pourcel concluded :

1. That the motor may be compared to the old horse-drawn vehicle which it has replaced, and on which it marks a considerable progress, but not to the railway which is of a different category.

2. That the superiority of the motor over the horse-drawn vehicle displaces the limit within which there is an advantage in resorting to through transport by one vehicle from end to end rather than by double cartage and by rail. The alteration in the cost of cartage demands a modification in the railway rates.

Defining the respective spheres of the motor and of the railway, M. Pourcel remarks that « the ideal would be for each transport to make use of the means or combination of means which fits it best, that is to say, that which it would take if the user, the transporters, and the State itself were one and the same person ». — « In order that the traffic may be distributed between the two modes of transport according to their natural qualifications to receive it, it is of course necessary that the legal and fiscal control of the two means of transport should not falsify, to the detriment of the public interest, their relative situation. There

is a profound difference in this respect between the motor and the railway. Not only does the latter bear much heavier taxes, but in addition, and above all, the motor uses gratuitously the roads constructed and maintened at the expense of the community ».

The motor tours, organised by the Paris, Lyon & Mediterranean Railway ever since 1911 [1], were the forerunners of the recent organisation by all the principal French Railways of ancillary Motor Transport Companies. Each ancillary Company is a general undertaking for cartage and correspondence service in the region served by the main railway system, and the chief secondary railway systems of the region also participate. The object of the Company is to co-ordinate the services, and to fix the rates, to develop the feeder and extension services of the railway, and to restore to the railway the transport which it can effect more cheaply or under better conditions, and finally to give to the public the maximum guarantees for efficiency of service.

The Rome Congress, on M. Pourcel's proposal, passed the following resolution :

That efforts should be made in every country to ensure collaboration between the motor and the railway to the best interests of the public, that is to say, in such a way that each transport is effected as far as posible by the cheapest way.

That, in particular, the legal and fiscal control of traffic, which it is desirable should be made as free as possible, shall not stand in the way of the realisation of the present resolution.

(1) World Motor Transport Congress, London, 1927, Proceedings, page 287 and *Bulletin of the Railway Congress*, July 1928 number.

**2. Motor competition and the « Railway (Road Transport) Act » of 1928 in Great Britain.**

A paper read at the London Congress in 1927 by Messrs Peterson and Osler, and the subsequent discussion, prove that in England, as in the United States, motor transport is in a state of active competition with the railways.

A paper by Dr. Fenelon on transport by road and rail in Great Britain, read on 7 September 1928 before the Economics section of the British Association in Glasgow [1] gives some idea of the present position of this question in that country. Referring to the enormous expansion of motor traffic since the War (in 1928 there were eight times more motor vehicles on the roads in Great Britain than in 1919), and the traffic losses of the railways owing to the motor competition, Dr. Fenelon points out the danger for the community in the falling off of railway traffic, and makes a plea for the railways in Great Britain to be given the power to utilize the roads, which they were prevented from doing by law, except as auxiliary transport at the railway stations. Competition has failed to provide a solution and should be replaced by co-operation so that each system can function in the conditions most suited to its economic character.

According to Dr. Fenelon, the different systems of co-ordinating road and rail transport may be grouped in three categories : 1. voluntary co-operation, 2. road transport under the direction of the railways, and 3. semi-legal co-ordination.

Voluntary co-operation has been tried by some of the railway companies, but it

(1) Railway Gazette and in abstract the January 1929 number of the International Railway Congress Bulletin.

has been difficult to carry out on a large scale whereas in Great Britain, the road transport is in the hands of numbers of small owners, and where new services can readily be set up. Transport services placed under the direction of the railways would be in reality their auxiliary services, capable of being used as a weapon against the other road transport undertakings and of setting up competition between the four principal railway systems.

In the form of semi-legal co-ordination, the different transport undertakings would be obliged to come to some agreement to form a co-operative system. This kind of co-ordination would involve recognition of a form of monopoly, obligatory participation in the organisation, and a control in the public interest.

Dr. Fenelon states that the present indications are that some form of co-ordination will have to be adopted, but he is afraid of the monopoly and public statutory control which would ensue, and which would cramp the liberty of the undertaking. He is of the opinion that voluntary co-ordination between the railways and the large transport companies would be the easiest solution; still, if it cannot be realised, it would appear that there is no other solution than to introduce some form of semi-legal co-ordination.

By the Railway (Road Transport) Act of 1928, the railway companies in Great Britain obtained the right of owning and running themselves motor vehicles, and of concluding agreements with the local authorities and private transport undertakings, with the view of a co-ordination of the services, and they have not been long in profiting by this. The principal railway companies have concluded agreements with some road transport undertakings, have bought up others, and have extended their own services of motor lorries.

### 3. Reports of the Commissioner of the German Railways to the Reparations Commission on motor competition in Germany. German regulations of 20 October 1928.

The reports of the Commissioner of the German Railways to the Reparations Commission, published annually in the *International Railway Union Bulletin*, contain very interesting information regarding the competition of motor transport in the extensive region covered by the German Railways. These reports show that during the past few years the number of motor vehicles in use in Germany has grown at an increasing rate, and that their competition with the railways, in view of the fact that they do not bear the expenses of constructing and repairing the roads. This competition is aggravated by an excessive policy of support and subsidy by the State and Provinces. The more important motor services are run by the Department of Posts, but there is no information to show whether these services are profitable or whether the losses are made good from other revenues of the Department.

In seeking means to improve the distribution of the traffic, and to obviate the enormous losses in the railway receipts, estimated in 1927 in goods traffic at 150 million marks, and in passenger traffic at 100 million marks, owing to road competition, the Reichsbahn, on the advice of a Commission appointed in 1927 to study this question, considered that the most suitable procedure would be to continue and extend the collaboration with the private motor transport undertakings

begun in 1924. The Reichsbahn had also sought to acquire control of the affairs of some Companies by buying up their shares, but this measure was not found to be very effective, and was soon abandoned. Seventeen motor undertakings then combined to form a single Company, the « Kraftverkehr Deutschland » which concluded a contract with the Reichsbahn by which the two parties promise not to conclude any agreements except with those motor transport undertakings that are amalgamated with the above-mentioned Company, and to organise, in common, motor services for the transport of passengers and goods, called « Eisenbahnkraftwagen-Verkehr ». The combined services were not developed to any great extent, and for this reason and also so as to be able to conclude agreements with the Department of Posts, and to operate itself certain motor services, the Reichsbahn cancelled the agreement with the « Kraftverkehr » Company by private contract on 15 November 1928.

A month previous, on 20 October 1928, an executive regulation of the Act of 1925 relating to motor services was published. This regulation gives a strict definition of a motor service and the condition on which authorisation to run them may be granted. The authorisation is personal, and it is only granted to a person offering the necessary guarantees for the security and the satisfactory working of the undertaking. Before authorisation is granted it must be preceded by an inquiry of the public transport undertakings of the region, as well as of the bodies whose duty it is to keep the road in repair. It may be refused « if the undertaking is preparing unfair competition with existing means of transport, or if it anticipates their reorganisation to the better satisfaction of the public interests, without itself satisfying those interests, in a more suitable or lasting manner, or without completing advantageously the existing means of transport » (1).

As will be seen from these details the new German regulations enable the State to apply measures sufficiently rigorous to ensure coordinated motor transport services and other public means of transport.

**4. The question of the competition between rail and road in the programme of work of the International Railway Union.**

At the 7th meeting of the Management Committee of the International Railway Union held in Paris, 8 and 9 November 1927, the Czechoslovakian Delegates proposed that an enquiry be made into suitable means for ensuring the rational distribution of traffic between the railways and the other means of transport (motor vehicles, aeroplanes). The Management Committee considered, however, that the study of this question ought not to appear among the subjects to be dealt with, because, in their opinion, it could scarcely be expected to provide a practical result as regards international traffic.

The Railway Company of the Bernese Alps, taking another standpoint, but without desiring to demand a revision of this decision, proposed at the meeting of the Union in Brussels, on 26 to 28 April 1928, that the question of the competition between railway and motor be included in the programme of work of the Union.

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(1) Dr. K. Giese, « Die neue Kraftfahrlinien Verordnung (The new motor service regulations). *Verkehrstechnik*, 1929, Heft 19-20.

This proposal was accepted by the Management Committee of the Union who decided at its meeting in Paris on 20 November 1928 to entrust to a sub-commission composed of Germany, France, Great Britain, Holland, Italy, and Switzerland, the study of the question :

« Competition and co-operation in pasengers and goods traffic between rail and motor ».

Germany and Switzerland were instructed to draw up the report.

As a result, the Chairman of the passenger traffic and goods traffic Commissions of the Union drew up a very detailed questionnaire relating to this question which was sent in February and March 1929, to the Administrations, Members of the Union.

It is to be hoped that the work of the International Railway Union will shed fresh light on this question, and will contribute towards its solution.

## V. — Conclusions.

1. The increasing importance of motor transport and its competition with rail transport demand in the common interests of these two modes of transport, as well as in the public interest, a true appreciation of their respective values among means of communication as a whole, and a coordination of their services.

2. Motor transport has deprived the railways of the character of undertakings possessing the monopoly of economical and rapid communication between certain localities. Despite certain obvious tendencies to place motor transport and rail transport on the same footing, the legal regulations at present in force in different countries do not take into account the profound changes which have supervened in the situation of the railways. It must be recognised that these defects in the legislation form one of the principal causes of the unfair competition by motor transport, resulting in losses for the community.

3. The condition of open competition allowed in some countries where the purely formal authorisation of regular motor services, without due regard to the existing means of communication, and without sufficient guarantee of the civil responsibility of the concerns, renders the co-ordination of transport and the collaboration between large numbers of small rival concerns and the railways more difficult, and is unsatisfactory from the point of view of the public interest.

The authorisation of regular motor services in competition with the railways or with other means of communication already in existence, not offering to the public any other advantage than that which the existing means of communication are able to ensure, ought to be prohibited. Before the concession of any regular motor service is granted, the authorities who have the right to grant it, ought to be obliged to consult the local railway administrations on the matter.

4. To ensure, as far as possible, a close collaboration of the motor transport with the railways, and to combine them into a common plan of transport, the railways ought to enjoy the right of preference in obtaining the concession of regular motor services, and of profiting thereby.

5. The diminution in the railway traffic produced by motor competition, of varying extent depending upon the development of motor transport, the condition of this transport, and other local circumstances, is chiefly evident in short distance traffic (up to 50 and 100 km.)

(31 and 62 miles) and amounts to 5 to 17 % of the receipts of the trunk lines and to 20 to 40 % of those of the local lines from passenger traffic, and 6 to 10 % of the receipts from goods traffic.

6. The lack of detailed statistics regarding motor traffic does not enable one to appreciate the losses caused by the competition of regular motor services, independent of the losses caused to the railways by the competition of other modes of motor transport. Acccording to the figures provided by some administrations (Netherlands Railways, Swiss Federal Railways) the losses caused by the competition of irregular services, and by privately-owned cars and lorries are much more important in those countries where the motor traffic is highly developed.

7. The transport rates on regular motor services are, for passengers, as much as twice as great as those for 3rd class by rail, and for goods, several times greater than by rail. Consequently, the competition of the motor services with the railway is due to other advantages of motor transport than that of economy, as well as to certain drawbacks of rail transport.

8. One of the principal advantages of motor transport in passenger and goods traffic is the through transport from door to door without changing The railways are not in a position to counterbalance this essential advantage of motor transport, except by auxiliary arrangements by road in order to ensure their clients complete transport. Arrangements of this nature, in the shape of motor buses or lorries, organised by the railway administrations or in agreement with private undertakings, have been carried out by some railways or are being organised.

9. Among the other measures to meet road competition, the following have been applied with good results :

a) *Passenger traffic :*

The organisation of local services of light and frequent trains in the form of rail motor coaches and rail motor cars on lines where traffic is not heavy, with arrangements for frequent stops between stations; the organisation of through trains on branch lines, the organisation of excursion trains at holiday times; improvements in the connexions between trains at junctions and other time-table improvements.

b) *Goods traffic :*

Speeding up transport by means of through trains and full wagons, attached, in some cases, to passenger trains; reduction in the duration of transit and of delays at stations; improvements in the despatch of goods, especially parcels, with the view of facilitating their collection and delivery, and of speeding up their transport; speedier forwarding of goods after transhipment.

10. The unequal conditions in which the railways are situated, with respect to motor transport, as regards the obligation to effect transport strictly in accordance with the rates, have induced several governments (Denmark, Holland, Sweden, Czechoslovakia) to authorise special agreements between the railways and their clients for the transport at reduced rates of suitable quantities of goods. This measure, applied on condition that the charges sanctioned correspond to the price of transport under reasonable conditions by motor lorry, and that they assure a profit to the railway on the cost, has been found effective.

11. A large number of railway administrations have organised, or are organising, as an auxiliary undertaking, regular motor services intended to serve as an extension of the railway system or to run parallel to their own lines to meet the demands of heavy local traffic. Some of these administrations (Netherlands Railways, Swiss Federal Railways), have entrusted the operation of their regular motor services, as well as the cartage and related problems to limited liability companies which they have organised as independant concerns by providing the necessary capital. According to information received, the two types of auxiliary undertakings which have just been mentioned, promise excellent results in regard to the co-ordination and collaboration of the motor service with the railway.

12. The mixed service of through transport by rail and by regular motor services belonging to the railways or to other undertakings has been organised on some lines and is apparently extending.

13. Information from participant administrations and from other sources, proves that it has been possible on some railway systems to reduce the competition of road transport, which, on other systems, is very aggravated owing to local circumstances, by speeding up and improving the transport by rail, by organising regular auxiliary motor services, and mixed through transport services, and by other steps by the railway administrations supported by government legislatory measures.

These examples lead one to hope that road motor transport, suitably co-ordinated, will become a powerful auxiliary of the railways, assisting in the completion and development of communication to the advantage of the public interest.

To attain this object, the further study of the problem by the Administrations and the Congress is earnestly to be recommended.

*26 July 1929.*

APPENDIX I.

## II. — Summary of replies.

§ 1. — *Of what importance is motor traffic in the country to which belongs the area served by your railway? How great has been the development of this traffic during the last few years?*

*Please state if there are any official statistics on this subject, and from these statistics or any other means of information at your disposal state the number of vehicles in circulation, if possible for each year since 1920. Please distinguish the following classes of vehicles :*

a) *those intended for the transport of goods;*

b) *those used for passenger transport, and in this latter class : 1. buses and charabancs; 2. small vehicles (not more than 6 seats). Differentiate between private vehicles and those of the public town services.*

*Please give any other information which would make it possible to appreciate the distance covered by the above vehicles, such as the annual amount of petrol or similar combustibles used during these same years by these vehicles.*

The figures given in the replies from Denmark, Poland, Sweden, Switzerland and Czechoslovakia are taken from the official statistical year-books. The source of the figures for Finland, Norway, the Dutch East Indies, and the private lines of Sweden and Switzerland is not given. Statistics are lacking for Greece, Holland, and Yugoslavia. The figures for Greece are only approximate.

The figures given in the replies which refer to the last statistical year have been inserted in table I below. Seeing that the statistical data of the replies refer to different periods it has been thought expedient to calculate from these figures the average annual increase expressed as percentages, so as to enable a comparison to be made between different countries. This increase, and the number of inhabitants per vehicle, are given in the table.

It has not been possible to give for any country the consumption of fuel by motor vehicles.

§ 2. — *What areas are covered by the regular motor services, whether bus or lorry, in the region served by your railway, and what has been their development during these last few years?*

*Please give the number and length in kilometres of the regular motor routes near your railway which could have any influence on its traffic.*

*Tabulate if possible this information for each year since 1920.*

The number and length of the services for recent years, together with the length calculated per 100 km² for each country are given in table I below. Instead of giving the figures for the previous years, which refer to different periods, it has been thought preferable to give the average increase per annum.

§ 3. — *What proportion of the total mileage given in paragraph 2 is covered by regular motor services between places already joined by the railway, these motor services being more or less parallel to the railway and therefore liable to compete with it?*

*Indicate if possible the annual differences in services of this kind since 1920.*

Table I gives, in addition to the extent figuring in the replies, the length of the

services expressed as percentages of the length of the railway system.

§ 4. — *What is the passenger and goods traffic of the competing services mentioned in paragraph 3, and how much has this traffic increased during recent years?*

*Please state for 1927 and as far as possible for every year since 1920 the number of buses and motor lorries (each class of vehicle separately) which have run regularly on these routes, the number of passengers and tons of goods carried yearly as well as the number of passenger-kilometres and tonne-kilometres.*

See table I below.

§ 5. — *What regulations are imposed in your country in the case of the regular motor services?*

*Please indicate the conditions demanded by the public bodies (State, departments or provinces, towns, etc.) of the companies organising and working regular motor services and especially :*

a) *Are the regular motor services necessarily the object of concessions or licenses which need administrative intervention? If this is so give the division of the lines dealt with under both paragraph 2 and paragraph 3 as between lines entirely free, and lines simply subjected to the obtaining of formal authorisation without any other participation of the public authorities as to clearly definited obligations concerning the extent of the service and the financial intervention of the said authorities.*

**Denmark : State.** — According to the Act of 4 July 1927 the licence for operating motor passenger or goods motor vehicles is granted by the municipal administration in whose jurisdiction are situated the roads to be used for the said vehicles. This licence has to be confirmed by the Minister of Public Works who investigates the bearing which the motor traffic in question may have on the railways, postal service and tramways enjoying concessions previously granted, and who may require the concession to be revised.

**Finland : State.** — All the regular motor services are subject to official authorisation. When it is a question of regular traffic between places situated in different prefectures, the authorisation is granted by the Minister of Roads and Communications, and in the other cases by the prefectorial administration.

**Greece : State.** — Motor traffic is not subject to any special conditions. No concessions.

**Norway : State.** — The operation of regular and public services for the transport of passengers and goods by motor is subject to the previous authorisation of the Bridges and Roads department of the province on the advice of the districts concerned. As regards the motor services subsidised by the State (vide 5 c), the organisation of the services and the rates is subject to the approval of the Minister of Public Works.

**Holland : State.** — In order to establish a regular passenger service, application for a concession has to be made to the provincial government, who considers it from the point of view of the existing means of communication. The contesting parties may appeal to the Crown. The concessioned service has to satisfy certain legal formalities before it can be put into operation, and the rates and time-table are subject to the approval of the said provincial government. No concession or authorisation is required to operate motor services intended for goods traffic.

**Dutch Indies : Sumatra.** — Almost all the regular motor services belong to the State (Department of Railways and Tramways).

**Dutch Indies : Java.** — A general law for motors is in preparation but does not exist yet. Operators do not require any concession.

**Poland : State.** — The operation of regular motor services is subject to the administrative authorisation of the province on the advice of the Directorate of Public Works. When the undertaking affects two or more provinces, the authorisation is granted by the Minister of Public Works. Authorisation is only granted for one year. A new law relating to concessions for regular motor services is under consideration.

**Sweden : State.** — Authorisation by the prefect of the department who takes into consideration the necessity and the expediency of the projected service, and may subject the authorisation to various conditions. For the local service of a town, the authorisation of the municipal police is required.

**Switzerland : Federal.** — The services for the transport of goods by motor are not yet subject to any concession. Preparations are in progress, however, to legislate for the control of motor traffic. According to the Federal Postal Services Act of 2 October 1924, the Postal Administration has the exclusive right of carrying passengers by regular services, provided this right is not restricted by other Federal Acts.

Concessions (A concession) may be granted for regular passenger transport to special undertakings. There are, moreover, the special regulations of 8 February 1916 relating to concessions for motor transport services. The undertakings benefiting by a concession are subject to the laws of civil liability of the railways, steamboat services and postal services, and to the provisions of the inter-cantonal compact, intended to effect uniform control of motor and cycle traffic, besides the other cantonal decrees relating to motor traffic undertakings. The undertakings profiting by a concession are subject to the Federal legislation relating to the length of working hours in the postal services. They are obliged to form a relief and provident fund for their employees in case of sickness, or to insure their employees with a Swiss insurance company, and to insure their passengers and employees against accidents with a Swiss company.

The granting and the renewal of the A concessions takes place at the instigation of the General Management of the Posts, which beforehand consults the Secretariat of the Swiss Department of Railways, the interested cantonal authorities, and, through their intermediary, the local authorities. A concession is usually granted for 10 years. On the concession expiring, the Confederation has the right to take over the service on its own account, and to acquire by paying a just indemnity, the rolling stock and, if the case arises, the fixtures.

During the entire period of the concession, the undertaking is placed, from the technical point of view, under the supervision and control of the General Management of the Posts.

The regulations relating to the granting of concessions to motor transport undertakings are at present being revised with the object of bringing them into line with the Federal Postal Services Act of 2 October 1924.

The motor tours organised in recent years by undertakings do not come within the scope of the A concession. The regular and public transport of tourists (circular tours) is subject to a B concession. This B concession only enables the holder to operate regular services in which the passengers are returned to their point of departure. The concessionnaire is not obliged to operate the services regularly. This concession also is granted by the Federal Department of Posts and Railways on the advice of the General Management

TABLE I summarising the r

| Question. | — | Denmark, State. | Finland, State. | * Greece, State. | Norway, State. | Dutch East |
|---|---|---|---|---|---|---|
| 1 | Number of motor vehicles in the country, and their increase in recent years : | | | | | |
| | *a*) Motor lorries | 15 548 (3) | 6 185 | 180 | 9 000 | |
| | Annual percentage increase | 24 | 58 | ... | 21 | |
| | Number of inhabitants per vehicle | 223 (3) | 559 | ... | 310 | |
| | *b*) Motor buses and coaches | 920 (3) | 1 286 | 70 | 1 200 | |
| | Annual percentage increase | ... | 49 | ... | 9 (6) | |
| | Number of inhabitants per vehicle | 3 770 | 2 740 | ... | 2 320 | |
| | *c*) Small cars in public service | ... | ... | ... | 2 800 | |
| | *d*) Private cars | 59 126 (3) | 16 905 | ... | 21 000 | |
| | Annual percentage increase | 25 | 72 | ... | 25 | |
| | Number of inhabitants per vehicle | 59 (5) | 208 | ... | 133 | |
| | Number of inhabitants per vehicle of all kinds (*a*, *b*, *c*, *d*). | 46 | 151 | ... | 82 | |
| 2 | Number and length of regular motor services in the zone of the railway, and its increase in recent years : | | | | | |
| | Number of services | 525 (2) | ... | ... | 614 (2) | |
| | Length of services, km. | 14 108 (2) | ... | 800 | 17 708 (2) | 1 |
| | Length of services per 100 km² | 32.9 | ... | 0 7 | 5.5 | |
| | Annual percentage increase | ... | ... | .. | 11 | |
| 3 | Number and extent of competitive regular motor services : | | | | | |
| | Number of services | 308 (1) | .. | .. | Small | |
| | Length of services, km. | 10 839 (1) | ... | 500 | Small | |
| | Length of services expressed as a percentage of extent of railway system | 213 | ... | 16 | ... | |
| 4 | Number of vehicles and distance travelled by passengers and goods on competitive motor services : | | | | | |
| | *a*) Number of motor lorries | ... | ... | ... | ... | |
| | Weight of goods, tonnes | .. | ... | ... | ... | |
| | Tonne-kilometres of goods | ... | ... | ... | 2.4 (7) | |
| | *b*) Number of buses or coaches | 400 | ... | ... | .. | |
| | Number of passengers, millions | ... | ... | ... | ... | |
| | Number of passenger-kilometres, millions | .. | ... | .. | 58.0 (7) | |
| | Annual percentage increase | ... | ... | .. | ... | |

(1) 1925-26.
(2) 1926.
(3) 1926-27.
(4) 1928.

questions 1-4 of the questionnaire

| Indies, Java. | Poland, State. | Sweden, State. | Sweden, Stockholm-Roslagen. | Sweden, Nora-Bergslagen | Switzerland, Federal. | Switzerland, Rhætian Railway. | Czechoslovakia, State. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 78 | 4 896 (4) | 26 230 | 7 180 | 66 | 10 941 | ... | 6 400 (2) | Unless otherwise stated the figures refer to 1927. |
| ... | 26 | 22 | 13 | ... | 13 | ... | 35 | |
| 00 | 6 040 | 231 | ... | ... | 362 | ... | 2 240 | |
| 11 | 2 841 (4) | 1 827 | 297 | 5 | 815 | ... | 676 (2) | * Approximate figures, statistics lacking. |
| ... | 31 (6) | 22 | 20 | ... | ... | .. | 52 | |
| 00 | 10 400 | 3 320 | ... | . . | 4 860 | ... | 21 200 | ...No figures available. |
| ... | 6 016 (4) | ... | ... | ... | ... | ... | ... | |
| 05 | 15 670 (4) | 81 465 (5) | 12 610 | 1 522 | 42 369 (5) | ... | 16 880 (2) | |
| ... | 29 | 22 | 17 | ... | 25 | ... | 36 | |
| 30 | 1 890 | 75 | ... | ... | 93 | ... | 850 | |
| 00 | 999 | 56 | ... | ... | 73 | ... | 600 | |
| 19 (2) | 980 | 1 500 | 11 (4) | 11 | 383 | 7 | ... | |
| 54 (2) | 40 002 | 40 000 | 353 (4) | 294 | 4 342 | ... | 17 068 | |
| 0.4 | 10.3 | 8.9 | ... | . . | 10.5 | ... | 12.1 | |
| .. | 26 | ... | ... | ... | 17 | ... | ... | |
| .. | 332 | Large | 5 (4) | 9 | ... | ... | ... | |
| 1 (1) | 16 453 | Large | 181 (4) | ... | 215 | ... | ... | |
| .. | 85 | ... | 1 | . . | 4 | ... | ... | |
| . | ... | ... | ... | ... | ... | ... | ... | |
| . | ... | ... | ... | ... | 0.02 | ... | ... | |
| . | ... | ... | ... | ... | ... | ... | ... | |
| . | 402 | .. | 25 (4) | ... | 17 | ... | ... | |
| . | 41.5 | ... | 1.02 (4) | 0.03 | 0.5 | 0.13 | ... | |
| . | 356.6 | ... | ... | 0 7 | ... | 2 4 | ... | |
| . | ... | ... | 38 | ... | ... | ... | ... | |

ncluding vehicles in public service.
'ehicles of the public services.
'otal traffic of the regular motor services most of which are not in competition with the railways.

of the Posts. It is valid for the current civil year. The other conditions are similar to those relating to A concession.

**Czechoslovakia : State.** — Authorisation by the technical administrative bodies. The Postal Administration establishes its services in accordance with the Post Office privileges. At the same time, it acts in consent with, and respects the objections raised by, the Administration of the State Railways. Privately-owned authorised motor services, while subordinate to the control of the administrative bodies, are only subject to that control to a limited extent and within the limits stipulated by the technical regulations.

b) *Are the regular lines of motor services having a concession part of a general plan that has in view the best possible method of meeting the needs of the country or is the concession-holder free to decide upon their direction?*

**Denmark : State.** — A general plan for regular motor services which may be authorised is not in existence. The licence granted by the local authorities fixes the routes over which the concessionnaires desire to run their services with the modifications which the authorities interested consider necessary to make.

**Finland : State.** — The concessionnaire is free to choose the direction in which the service is to run. At the same time, in granting the authorisation, the general value of the service in question is taken into consideration.

**Norway : State.** — The concession granted for regular motor services generally only applies to a definite route or routes. As regards the services which are not subsidised by the State, the authorisation is principally subject to the needs proper to the district, taking into account the means of communication already in existence. In subsidising certain regular services, the tendency of the State is to maintain the operation of services where the traffic is light if it considers that the question is one of public interest and that these regular motor services cannot be organised or run advantageously in any other manner.

**Holland : Netherlands State.** — In considering applications for concessions, the existing means of communication are taken into account.

**Dutch East Indies : Sumatra.** — The regular motor services, belong almost entirely to the State, and form part of a definite system of communication.

**Dutch East Indies : Java.** — The company is free to choose the routes in which the service is to operate.

**Poland : State.** — There is no general plan of regular motor services. The companies are free to choose the routes of the services regarding which application for authorisation is made.

**Sweden : State.** — There is no general plan.

**Switzerland : Federal.** — The concessions of regular motor services are not granted according to a general plan, but as the need arises. As the competent authority for granting these concessions is the Department of Posts and Railways, it is in a position to make a careful examination, on each application, of the question of the necessity of the service to be instituted, and to submit the application for judgment not only to the Administration of the Posts but to the Administration of the Federal Railways also. By means of this regulation it has been possible to avoid sanctioning motor services which would constitute a serious competition to the railways. The existing motor services satisfy a real need, because they serve districts which are not reached by the railways, and thus form a useful adjunct to our system.

**Czechoslovakia : State.** — The privately-owned motor services are not established in accordance with any general plan whatever. As regards both the direction of the route and the intensity of the service, the initiation is left to the judgment of the concessionnaire. The Administration of the State Railways meets with the support of the administrative bodies in the sanctioning of services, in that these bodies ask its opinion, and its objections are generally respected provided they prove that the railway system satisfies the local conditions.

c) *Are the concession-holders of regular motor services sudsidised by public authorities? What are the public bodies that bear the weight of these subsidies? How are they decided upon, divided, and assigned?*

**Denmark : State.** — With the exception of a few services, which transport the post at an agreed price, the motor services do not enjoy subsidies from the public authorities.

**Finland : State.** — No subsidies.

**Norway : State.** — In recent years, Parliament has voted a general subsidy to all the regular motor services. In 1920 this subsidy was about 200 000 Norwegian crowns (about 278 000 gold-fr.) and in recent years it was 450 000 crowns (625 500 gold-fr.). The credits voted are distributed by the Minister of Public Works among about 140 services in accordance with the principles set forth earlier on. The more important subsidies apply to the less populated regions, less provided with means of communication. In subsidising certain regular services, the tendency of the State is to maintain the operation of services where the traffic is light, when it considers that the question is one of public interest, and that these regular motor services cannot be organised or run advantageously in any other manner.

**Dutch East Indies : Java.** — No subsidies.

**Poland : State.** — No subsidies.

**Sweden : State.** — No subsidies.

**Switzerland : Federal.** — In certain cantons (Fribourg, Glaris, Geneva, Obwalden) the cantons and communes interested grant subsidies to the concessionnaires of regular motor services. These subsidies depend upon the financial position of the canton and communes, and upon the services rendered by the undertakings in question. In other cantons (Vaud, Neuchâtel, Schaffhouse, Soleure, Tessin, Thurgovia) the public authorities bear a portion of the working losses. But in the majority of the cantons, the State and the communes do not grant any subsidies and bear no share in the losses. The payment of the subsidy or the share of the losses generally takes place at the end of the financial period.

**Czechoslovakia : State.** — No subsidies. The State Postal Administration establishes its motor services only on the condition of certain guarantees on the part of the districts which have applied for the services.

d) *Do the regular motor services, whether free, authorised, or the object of a concession, bear a part of the construction and upkeep expenses of the roads used by them. If so how much and in what way? What taxes are imposed on them? Compare these expenses and taxes with those borne by rail transport.*

**Denmark : State.** — Motor vehicles and trailers provided with pneumatic tyres are taxed as follows :

| Net weight of vehicle, kilogrammes (pounds). | Tax per 100 kgr. (220 lb.) of net weight. | | | |
|---|---|---|---|---|
| | Vehicles for passenger traffic. | | Vehicles for goods. | |
| | Crowns. | Gold-francs. | Crowns. | Gold-francs. |
| Up to 1 000 (2 205) . . . | 10 | 13.90 | ... | ... |
| 1 001 — 1 200 (2 207 to 2 645) | 12 | 16.68 | 13 | 18.07 |
| 1 201 — 1 500 (2 647 to 3 307) | 15 | 20.85 | 16 | 22.24 |
| 1 501 — 2 000 (3 309 to 4 410) | 17 | 23.63 | 18 | 25.02 |
| 2 001 — 2 500 (4 412 to 5 516) | 20 | 27.80 | 20 | 27.80 |
| Above 2 500, 1 crown for every additional 100 kgr. (220 lb.) to a maximum of . . . . . | 25 | 34.75 | 30 | 41.70 |

For vehicles fitted with semi-solid tyres the taxes are increased by 25 % and for those with solid tyres, by 50 %.

The motor spirit is subject to a tax of 7 öre (9.7 centimes) per litre (44 gold-centimes per Imp. gallon).

The revenue from the above-mentioned taxes is used in the upkeep and improvement of the roads and has to be distributed among the districts, the towns, and counties according to rules laid down by law.

The State Railways do not pay any special taxes.

**Finland : State.** — If the motor services make use of communal or parish roads, the commune or the parish has the right to charge these services with the maintenance expenses of part of the roads, but the State has not the same rights in respect to its roads. There are no other taxes excepting the cost of the registration stamp.

**Greece : State.** — No.

**Norway : State.** — The users of motor vehicles in Norway share in the upkeep of the roads by paying road taxes, the revenue from which is distributed among the counties according to the estimated traffic.

In 1927, the 41 000 motor vehicles, consisting of 34 000 motor cars and 7 000 motor cycles, paid the following road taxes :

| | Norwegian crowns. | Gold-francs |
|---|---|---|
| 1. Tax applied on the basis of the weight of the vehicle (6 crowns = 8.34 gold fr. per 100 kgr. (220 lb.) . . . . . . . . | 2 700 000 | 3 753 000 |
| 2. Tax on pneumatic tyres and solid tyres (1.50 crowns = 2.09 gold fr. per kgr. (2.20 lb.). . . . . | 1 300 000 | 1 807 000 |
| | 4 000 000 | 5 560 000 |
| Share allotted to towns. . . . . . . | 200 000 | 278 000 |
| Thus leaving for rural roads . . . | 3 800 000 | 5 282 000 |

During the same year, the users in addition paid 1 500 000 crowns (2 085 000 gold francs) in luxury tax, 600 000 crowns

(834 000 gold francs) in control tax, 3 000 000 crowns (4 170 000 gold francs) in obligatory insurance premiums, and the customs duties above those collected on the engines, the supplementary revenue from which amounted to 3 400 000 crowns (4 726 000 gold francs).

The last-mentioned duties and taxes are not used for the upkeep of the roads.

The regular motor services are all subject to the same duties and taxes, but they may in addition be charged with special royalties for the road maintainance, their payment being a condition on which the concession is granted.

The Norwegian State Railways are relieved from all duties and taxes.

**Holland : Dutch State.** — Every owner of a motor vehicle, unless exempted for some reason or other, pays a tax for the construction and maintainance of the roads (State contribution).

**Dutch East Indies : Sumatra.** — In some cases a slight payment (3 cent. florin = 6 gold centimes per km.) (9.6 gold-c. per mile) has to be made for the upkeep of the roads.

**Dutch East Indies : Java.** — The central government does not collect taxes on motor vehicles. The direct taxes for the construction and maintainance of the roads are levied by the local authorities, according to the total number of tonne-kilometres or above a certain number of tonne-kilometres. Apart from the road tax, motor vehicles bear local taxes. These taxes vary considerably. A 2-ton motor lorry, for example, is liable for sums varying between 36 f. and 450 f. per annum, and a 5-ton lorry for sums varying between 36 f. and 1 000 f. per annum.

Indirect taxes are collected in the form of import duties on motor vehicles, accessories, and pneumatic tyres. The revenue from these taxes amounted to 3 600 000 f. in 1926. There is also an indirect tax on motor spirit (7.5 ct. = 15.6 gold centimes per litre, 70.8 gold-c. per Imp. gallon) the revenue from which amounted to 9 800.000 f. in the same year.

It is difficult to make a comparison with the taxes affecting railways, owing to the wide variation in the taxes on motor vehicles.

**Poland : State.** — The undertakings of regular motor services may by law be obliged to share the upkeep expenses of the roads, but the authorities only rarely exercise this power, and then to a slight degree. For instance in the Lwow province 2 gros (1.2 gold centimes) are collected per tonne-kilometre (1.9 gold-c. per Engl. ton-miles) of the distance covered by motor vehicles.

The regular motor services have to bear, in addition to the industrial tax depending upon the extent of their turnover, and in addition to the ordinary charges, small charges for the registration of the undertaking and of the vehicles, and occasionally tolls on entering certain towns or crossing certain bridges.

The railways are exempt from taxes but they bear all the costs of construction and maintenance of the railways, and in addition a town-due on goods, which is not applied to other means of transport.

**Sweden : State.** — Motor transport is burdened with the following taxes :

1. For each 100 kgr. (220 lb. of the weight of a vehicle 10 kronor (13.9 gold-francs).

2. For each kgr. (2.2 lb.) of pneumatic tyres, 1 krona 75 öre (2.43 gold-francs).

3. For each litre (0.22 Imp. gallon) of motor spirit, 6 öre (8.3 gold centimes).

The receipts from these taxes are utilised for the construction and upkeep of the roads. Moreover, the prefect of the department, in authorising a regular service, has the power of imposing a special charge if it is found that the upkeep costs of the road in question are excessively increased by the traffic of the regular

service. In reality, however, such charges are rarely imposed. As for the railway traffic, there are no special taxes.

**Switzerland : Federal.** — The Fribourg canton alone demands a special contribution from the regular motor services for the upkeep of the roads in addition to the ordinary taxes (on property, income, and the tax on motor vehicles).

In the cantons of Schaffhausen, Solleur, Obwalden, Appenzell R. ex., Neuchâtel, and Vaud, the motor services which have been given the privilege of a concession are exempt from the tax on motor vehicles. In the cantons of Glaris and Tessin they have only to pay a reduced tax. In all the other cantons, the concessionnaires are subject to the ordinary taxes and charges (including the tax on motor vehicles).

The Federal Railways are exempt from all taxes and cantonal and communal charges.

The duties to be paid in order to obtain a concession are 250 francs, plus an additional charge of 25 francs per kilometre (40 fr. per mile), the distance being reckoned in a straight line.

**Czechoslovakia : State.** — From 1 October 1927, the owners of motor vehicles have been subject to the tax on motor vehicles. In addition the motor bus fares are subject to tax, like the railway fares (i. e. 30 %). Still, and in this respect it differs from the tax on transport by rail, this tax may be reduced or annulled altogether if there is no parallel communication by rail. The Minister of Finance, in agreement with the Minister of Railways and the Minister of Posts, is authorised to exempt motor bus fares partly or entirely from tax. The exemption from this tax is fairly liberal, so that only those motor bus services presenting a character of pure competition with the railways are burdened with the full 30 % tax. The revenue from the taxes on motor vehicles, and the taxes on motor bus fares, being put to the road fund, is intended for the improvement of the condition of the roads to the benefit of the motor traffic.

e) *Are the rates of regular motor services, whether free, authorised or the object of a concession, submitted to the approval of the public authorities ? (which?) or simply decided by the concession-holders?*

**Denmark : State.** — The rates are fixed in the licence referred to under 5-a.

**Finland : State.** — The rates are subject to confirmation by the prefectorial administration.

**Greece : State.** — The rates are not subject to confirmation.

**Norway : State.** — As regards the subsidised services, the rates are fixed by the Minister of Public Works, as regards the other services, by the Service of Roads and Bridges of the district concerned.

**Holland : Netherlands State.** — Passenger rates and time-tables are subject to the approbation of the provincial government. The goods rates are free from control.

**Dutch East Indies : Sumatra.** — No information.

**Dutch East Indies : Java.** — In general, the companies are free to fix their own rates. In some regions, the maximum rates are fixed by the local authorities.

**Poland : State.** — The companies are free to fix for themselves the rates on their services.

**Sweden : State.** — The maximum rates are fixed by the prefect of the department.

**Switzerland : Federal.** — The charges for passengers and goods are subject to the approval of the General Management of the Posts.

**Czechoslovakia : State.** — The fares on the regular motor bus services are subject to the approval of the technical administrative authorities. The rates for goods traffic are fixed freely by the concessionnaire.

f) *Are the concessions of regular motor services monopolies for the working of those routes or is there open competition either between themselves or with such regular services as are not the object of a concession (free or simply authorised)?*

**Denmark : State.** — The licence does not imply any monopoly and other authorisations to run vehicles either entirely or partly along the same roads may be granted if such is considered in the public interest.

**Finland : State.** — Competition is left open between the authorised services.

**Greece : State.** — Competition is open.

**Norway : State.** — The concessions do not bear the character of monopolies for operating the services decided upon, because it is possible for several companies to be concessionnaires on the same route. Competition is, however, not any more open on that account, because the concession may impose certain special rules and conditions intending to prevent unfair competition between the concessionnaires. On the other hand, all the regular motor services are exposed to the competition of taxis and motor lorries which only require the authorisation of the local police.

**Dutch East Indies : Java.** — Competition is open.

**Poland : State.** — Competition between motor services is open.

**Sweden : State.** — The authorisation or concession of regular motor services has not the character of a guaranteed monopoly. However, if the service is run in a satisfactory manner, it is very probable that the prefect will not grant authorisation to any other undertaking on the same route. The prefects generally take care that competition is restricted.

**Switzerland : Federal.** — The Postal Administration reserves the right to maintain or institute at any time postal services on the concessioned route (A concession) if this is considered expedient for any reason whatever, without being obliged to compensate the motor services. On the other hand no concession is granted to any other undertaking for a route already concessioned. The Department of Posts in the same way reserves the right to make, by the Administration of Posts, journeys along the same route as the concessioned circular route (B concession), or to grant other concessions for the same circular route.

**Czechoslovakia : State.** — The concessions of regular motor services have not the character of monopolies and a concession may be granted to several concessionnaires for the same route. In practice, however, the administrative body, authorised to grant the concession, takes into account the concessions already granted.

g) *Are there any enterprises (State enterprises, those of communes, etc., or those of certain railway companies) which enjoy a preference in the obtaining of concessions of regular motor service?*

**Denmark : State.** — The Minister of Public Works may authorise postal motor services without the consent of the local authorities.

**Finland : State.** — No such undertakings exist.

**Norway : State.** — No.

**Dutch East Indies : Java.** — No such undertakings exist.

**Poland : State.** — There are no undertakings enjoying a preference in obtaining the authorisation to operate a regular motor service. With the exception of two services (between Stary Sacz and Szczawnica, and between Rowno and Korzec) operated by the Management of the Posts and Telegraphs Department, all the regular motor services are operated by private undertakings.

**Sweden : State.** — No such preferences exist but prefects take into consideration legitimate interests.

**Switzerland : Federal.** — Such a privilege does not exist, but State undertakings or large private undertakings usually obtain the preference owing to the better financial guarantees they offer.

**Czechoslovakia : State.** — State undertakings do not enjoy any legal preference in obtaining the concession of regular motor bus services; still, the Administration of Posts, where it maintains a regular service, invokes its status of monopoly in accordance with the postal privileges.

§ 6. — *What are the passenger rates and the goods rates of the regular competing motor services? Are there any fixed regulations to determine the amount of these rates? What ratio is there between these rates and those of the railway on corresponding routes?*

*Please state the average and the maximum rates per kilometre in the current coin of the realm and in gold centimes and the ratio in percentages to the corresponding railway rates. How have these rates and this ratio developed in recent years?*

**Denmark : State.**

| | Öres. | Gold-centimes. |
|---|---|---|
| Passenger rates : | | |
| Maximum . . . . . | 33.0 | 45.8 |
| Minimum . . . . . | 4.5 | 6.3 |
| Average . . . . . . | 10.0 | 14.0 |
| Railway rates . . . . | 5.0 | 7.0 |

**Finland : State.** — There are no definite rules fixing the prices of transport by regular motor services. The prices of railway tickets are generally 50 % (often much more) cheaper than the prices of corresponding journeys by motor.

**Greece : State.** — No information.

**Norway.** — There is no rule determining the rates of the regular motor services. These rates are fixed according to circumstances by the authorities granting the concession. In accordance with the drop in the cost of living in Norway during the past few years, the rates of the period 1920-1923 have actually been reduced by about a half. In 1927 the rates were approximately as follows :

**Passenger :**

**Motor services** : 10 öres = 0.14 gold-fr. per passenger-kilometre (0.225 gold-fr. per passenger-mile).

**Railway** : 6 öres = 0.083 gold-fr. per passenger-km. (0.133 gold-fr. per passenger-mile).

**Goods :**

**Motor services** : 60 öres = 0.83 gold-fr. per tonne-kilometre (1.33 gold-fr. per Engl. ton-mile).

**Railways** : 8 to 9 öres = 0.11 to 0.125 gold-fr. per tonne-km. (0.177 to 0.21 gold-fr. per Engl. ton-mile).

**Holland : Netherlands State.** — The rates of regular motor services are generally higher than those of the railway. The advantage of the through transport from the consignor to the consignee is the reason why these rates can be higher than those of the railway.

**Dutch East Indies : Sumatra.** — No reply.

**Dutch East Indies : Java.** — No definite rules for fixing the rates.

| | Dutch cents | Gold centimes | |
|---|---|---|---|
| *Motor buses.* | | | |
| Passenger rates : | per passenger-kilometre. | per passenger-kilometre. | per passenger-mile |
| Maximum : 1st class . . . . . . . . | 5.3 | 10.6 | 17.0 |
| 2nd class . . . . . . . . | 4 | 8 | 12.8 |
| Minimum : 1st class . . . . . . . . | 1.7 | 3.4 | 5.5 |
| 2nd class . . . . . . . . | 1 | 2 | 3.2 |
| Average : 1st class . . . . . . . . | 3 to 3 ½ | 6 to 7 | 9.6 to 11.3 |
| 2nd class . . . . . . . . | 2 to 2 ½ | 4 to 5 | 6.4 to 8.0 |
| *Motor lorries.* | Per tonne-kilometre. | Per tonne-kilometre. | Per Engl. ton-mile. |
| Rates per ton and per km. : | 15 to 30 | 30 to 60 | 49 to 98 |
| *Railway rates.* | Per passenger-kilometre | Per passenger-kilometre. | Per passenger-mile. |
| 1st class . . . . . . . . | 8 | 16 | 26 |
| 2nd class . . . . . . . . | 4 | 8 | 13 |
| 3rd class . . . . . . . . | 2 | 4 | 6.5 |
| 3rd class natives . . . | 1.4 | 2.8 | 4.5 |
| | Per tonne-kilometre. | Per tonne-kilometre. | Per Engl. ton-mile. |
| Goods . . . . . . . . . . . . . . . . . | 15 to 30 | 30 to 60 | 49 to 98 |

**Poland : State.** — In 1927 the passenger rates of regular motor services varied between 8 and 12 gros = 4.6 to 7.0 gold centimes per km. (7.4 to 11.2 gold-c. per mile). The railway rates for journeys up to 100 km. (62 miles) amount to 6.6 gros for 3rd class and 9.9 gros for 2nd class (3.8 to 5.7 gold centimes per kilometre) (6.1 to 9.15 gold-c. per mile).

**Yugoslovia : State.** — The passenger fares on motor services parallel to the railway are 0.5 to 0.75 dinar (4.6 to 6.8 gold-centimes) per km. (7.4 to 10.9 gold-c. per mile) and 0.75 to 1.00 dinar (6.8 to 9.1 gold centimes per km.) (10.9 to 14.6 gold-c. per mile) on the other services.

**Sweden : State.** — The rates of the regular motor services differ greatly. The passenger rates vary between about 5 and 10 öre (7 and 14 gold-centimes per km.) (11.2 and 22.4 gold-c. per mile). Very often they are between 6 and 8 öre (8 and 11 gold-centimes per km.) (12.9 et 17.7 gold-c. per mile). On some very busy services near the large towns, they are only 4 to 5 öre (5.5 and 7 gold-centimes) (8 and 11.2 gold-c. per mile). Often the fares are reduced for long journeys.

The goods rates are probably 50 to 80 öre (0.70 to 1.11 gold francs) per tonne-kilometre (1.14 to 1.81 gold-fr. per Engl. ton-mile). The passenger rates on the State railways, expressed in öre per kilometre are fixed as follows :

| | Per kilometre. | Per mile. |
|---|---|---|
| 20 km. (12.4 miles) | 6.72 öre (9.3 gold-c.) | 15.0 gold-c. |
| 50 — (31.0 — ) | 6.39 — (8.9 — ) | 14.3 — |
| 70 — (43.5 — ) | 6.00 — (8.3 — ) | 13.3 — |
| 500 — (310 — ) | 3.80 — (5.3 — ) | 8.5 — |

The rates of private railways are generally higher.

Successive reductions in the railway rates have been made since 1920.

**Switzerland : Federal.** — The rates of the services competing with us in passenger transport are generally higher than those of the Federal Railways. In the statement which the railways are called to give regarding the concession to be granted, they always request, if they offer no direct opposition to the granting of the concession, that the rates of the motor

services shall not, in any case, be lower than the railway rates. Moreover, if the motor services are to remain solvent, they cannot make lower charges than they do.

As regards goods transport, the motor service is on an average 15 to 20 % cheaper than that of the railway.

Average price per 10 t. and per km. = 1.20 Swiss franc (1.96 Swiss franc per 10 Engl. ton-miles).

Average price per 5 t. and per km. = 0.90 Swiss franc (1.47 Swiss franc per 5 Engl. ton-miles).

**Czechoslovakia: State.** — The passenger rates of the postal services are on an average 60 hellers (9.2 gold-c., 14.8 gold-c. per mile), those of private services, 40 to 50 hellers (6.1 to 7.7 gold-centimes) (9.8 to 12.4 gold-c. per mile). These rates are about 100 % higher than the 3rd class fares of stopping trains. Usually this disproportion is compensated for by the journey by road being short in comparison with the journey by rail.

§ 7. — *Can you observe any diminution of traffic on your railway, directly attributable to the development of traffic on adjacent lines of regular motor services?*

*Please give as a percentage of the total traffic the probable diminution in the number of passengers and tons of goods for the whole distance and per kilometre of the distance on those sections of your railway where there is active competition.*

*How much has this loss increased during the last few years ?*

**Denmark : State.** — No information.

**Denmark : East Seeland.** — No. Compared with the traffic on our railway in 1925, the passenger traffic of 1927 has increased by 31 %, and the goods traffic has decreased by 9 %.

**Finland : State.** — From 1923 to 1927 the reduction in the number of passengers on the railway lines subject to the competition of motor traffic may be estimated at 20 %. A very considerable increase in the total receipts from passenger traffic, which occurred at the same time, was due partly to the increase in the long-distance traffic, and partly to the increase in the rates in 1925. As regards goods traffic, no reduction in tonnage has been noted.

**Greece : State.** — The reduction in the railway traffic caused by motor competition cannot be expressed in figures.

**Norway : State.** — It is impossible to tell what proportion of the reduction in goods traffic, observed in recent years, is due to the competition in motor traffic, or what proportion is due to other causes. For the years of operation 1925-1926 the losses in passenger traffic, **due to the competition of the whole of the motor traffic** are estimated at 11 % of the number of passengers, and 12.5 % of the receipts. The losses in goods traffic are estimated at 6.37 % of the net tonne-kilometres and at 6.85 % of the receipts. The total losses in passenger traffic and goods traffic resulting from the above-mentioned competition may be estimated at 8.65 % of all the working receipts. It is impossible to say what proportion of these losses is due to the competition of regular motor services.

**Holland : Netherlands State.** — The losses are considerable, as will be seen from the following figures for the receipts from passenger transport on the Dutch railways :

| | | | |
|---|---|---|---|
| 1916 . . . . | 49 | million | florins. |
| 1917 . . . . | 52 | — | — |
| 1918 . . . . | 60 | — | — |
| 1919 . . . . | 71 | — | — |
| 1920 . . . . | 87 | — | — |
| 1921 . . . . | 90 | — | — |
| 1922 . . . . | 87 | — | — |
| 1923 . . . . | 82 | — | — |
| 1924 . . . . | 80 | — | — |
| 1925 . . . . | 79 | — | — |
| 1926 . . . . | 76 | — | — |

**Dutch East Indies : Java.** — There has been a reduction in the passenger traffic

of all classes, but not in the goods traffic. From 1920 to 1926 the reduction was as follows : 1st class, 57 %; 2nd class, 50 %; 3rd class, 23 %, and 3rd class natives, 31 %.

**Poland : State.** — The development of adjacent regular motor services is undoubtedly causing a reduction in the passenger traffic of the Polish railways. This reduction is not yet very perceptible, seeing that in 1927 the passenger traffic of the competitive motor services only comprised 7.1 % of the number of passengers for any distance, and 5.5 % of the number of passengers for a distance of one kilometre.

**Yugoslavia : State.** — The motor traffic, especially that of the public services, has no effect on goods traffic and only affects the short distance passenger traffic.

**Sweden : State.** — It is impossible to distinguish between the influence on the railways of the regular services and that of the other motor traffic. Several private railways of local importance have suffered a considerable reduction in traffic, due undoubtedly to motor traffic. There are several instances of railways on which the number of passenger-kilometres and the number of tonne-kilometres have diminished by 20 to 40 % since 1913. On the State railways (and on several private trunk lines), however, the total traffic has increased considerably — passenger-kilometres and tonne-kilometres by about 25 % — but the short distance traffic has decreased.

**Switzerland : Federal.** — The competition of the infrequent adjacent motor services with our railways is insignificant, as regards both passenger transport and goods transport.

**Switzerland : Rhætian.** — Thanks to the laws in force, we do not yet fear any considerable competition from motors.

**Czechoslovakia : State.** — A reduction in the passenger traffic showed itself in 1927, and amounts to 7 1/2 % of the traffic of 1926 for journeys up to 50 km. (31 miles). It is certain that this reduction is caused in a large measure by competitive motor bus services.

§ 8. — *Besides the regular motor services considered in §§ 2 to 7 what is the importance of the passenger and goods transport carried out either by intermittent or irregular services, or by motors and lorries belonging to private individuals who use these either for their own needs only or also for their needs and on account of other people?*

*Indicate as in paragraph 7 the effects of this competition on the traffic of your railway.*

**Denmark : State.** — No information.

**Denmark : East Seeland.** — Not known.

**Finland : State.** — This competition is of little consequence to our lines.

**Greece : State.** — See reply to question 7.

**Norway : State.** — See reply to question 7.

**Holland : Netherlands State.** — Goods traffic in particular has suffered from the competition of haulage contractors serving the localities in the neighbourhood of towns of some importance. In addition, the large warehouses, factories, and other establishments are making increasing use of their own motor transport.

**Dutch East Indies : Sumatra.** — The revenue from the 1st and 2nd classes on the railways has decreased by 33 % from 1924 to 1927.

**Dutch East Indies : Java.** — Data are lacking.

**Poland : State.** — Statistical data are lacking. An increase in the goods traffic by motor lorry is noted, especially suburban traffic.

**Sweden : State.** — See reply to question 7.

**Switzerland : Federal.** — We estimate at 36 million francs the annual losses caused to the Federal Railways by motor competition, two thirds of this sum being attributable to goods traffic, and one-third to passenger traffic. These are approximate estimates. So long as the regular or occasional goods traffic by motor is not subject to concession, it is impossible to determine with any exactitude the figures relating to this traffic. Experience has shown that regular transport, of a professional character, of goods by motor from one locality to another on a given route is not of great importance. The largest part of the traffic taken from the railways is effected by business houses or industrial concerns on their own behalf or as a side-line on the behalf of third parties, so as to utilise the lorries. There are, in addition, motor haulage contractors (garage proprietors, etc.) who carry goods once or twice a day in all directions, and to varying distances, according to the needs of their clients. Such traffic has no time-table or route fixed beforehand.

At the present time there are, in Switzerland, nearly 800 concerns who carry goods by motor lorry for payment on behalf of third parties; some of them make a profession of it while others merely effect the transport as a side-line. Firms possessing motor lorries come to an agreement with those not possessing motor lorries, and let them know when a journey is going to be made in a given direction. As certain destinations are served fairly regularly, there is always a sufficient quantity of goods for transport. A real transport organisation has thus been formed which would be difficult to oppose, even introducing the obligatory concession, which, legally, would moreover encounter certain obstacles of a constitutional character,and which therefore it would be inconvenient to introduce here.

§ 9. — *Independently of the rates, what inconveniences have ben observed on your main and branch lines likely to cause passengers and consignors to make use of road rather than rail services.*

*Please indicate the mesures taken by your railway to accelerate transport, to make the service more frequent, etc.*

**Denmark : State. — Passenger traffic.** — Most of the passengers who prefer motor transport to rail transport make this choice in order to be transported directly without having to make the journey, however short, to the station. Often the direction followed by the motor bus services is preferred to that of the railway lines, as the journey is quicker. The time-tables of motor buses can take into account the needs of small localities more readily than railway time-tables. The number and the time of trains making connexions with branch lines often leaves much to be desired. Provided they are not crowded, motor vehicles are more comfortable than a 3rd class railway coach without upholstered seats. The simple form of operating the service, enabling tickets to be issued en route and stops to be made as desired, induces the public to use the motor bus.

To reduce the competition by motors, the State Railways have enlarged the time-table considerably. From 1922-23 to 1926-27, the train journeys have increased by 21 %. This increase refers almost entirely to passenger traffic. The passenger traffic has been separated from the goods traffic on lines on which previously the two kinds of traffic were effected by mixed trains. Through trains and through coaches running on branch lines have been established, as well as light motor trains to supplement the local time-table. The 3rd class coaches are gradually being fitted with upholstered seats.

**Goods traffic.** — The facility of transport from door to door which is offered by motors, personal propaganda by the concessionnaires, the offer of transport,

often possible at lower prices than the expenses of the concessionnaire, have had serious consequences for the railways. It is chiefly for goods despatched at ad valorem rates that motor vehicles are able to offer cheap transport on a very extensive scale.

Serious steps have been taken, on the part of the railways to reform the cartage at stations. Close contact has been established between the clients and railway employees specially appointed for this purpose, and in certain cases the transport of goods has been reorganised as occasion required, by organising fast trains. The re-despatch of goods from reloading stations has also been speeded up.

**Denmark : East Seeland.** — In passenger and goods traffic, convenience of transport from door to door. Means : reduction of rates, improvement of the timetable, organisation of a supplementary service of motor coaches and lorries.

**Finland : State.** — An effective cause of the competition in question is that the motor traffic is more flexible, often enabling a through journey to destination to be made. On our part, we intend to speed up transport, to make it more frequent and more direct, to use motor lorries for the goods traffic between the stations and our clients, and to collaborate with the feeder motor services.

**Greece : State.** — The desire to avoid changing at arrival and departure stations. We are considering the organisation of door to door transport in some important localities.

**Norway : State.** — The predominant part in the competition between railway and motor is that the trains are tied to the track, and that they only stop at stations, while motor vehicles follow the highways and roads, and can stop anywhere. As regards passenger traffic, the public making use of the railways have, therefore, a greater or lesser distance to go to or from the station. On the other hand, motor vehicles by following the road, run much more frequently through thickly-populated areas, may pick up passengers anywhere and take them to their destination. Consequently it is much more practical and much quicker, especially in the suburbs, to make use of the motor services.

As regards goods traffic, the motor vehicles have the advantage of being able to collect the goods to be transported at the actual place of despatch, and to deliver them directly to the consignee. The reduced railway rates only partly make up for the costs of transport to destination or on leaving the station, especially when it is a matter of short-distance parcels transport.

On the railway lines where the traffic is light, our Administration uses rail motor coaches for the transport of passengers and small parcels. These rail motor coaches stop between stations and consequently more frequently than the trains.

**Holland : Netherlands State.** — The motor services have the advantage over the railways, in that they can serve centres of population, and can transport passengers and goods to the door, whereas the railway stations are located at some distance from these centres.

We have been able gradually to increase our goods traffic by speeding up transport, by facilitating collection and delivery of goods door to door, by reducing certain rates, and also by publicity, but we do not know whether we have won this increase from the regular motor services or rather from other rivals (water transport, carriers).

**Dutch East Indies : Sumatra.** — The public prefer motor transport to rail transport for the following reasons : less limited speed and frequency, and the convenience of transport from house to house for passengers, and from warehouse to warehouse for goods.

In order to meet this competition, the speed and frequency of the trains, and the number of stops have been increased for the convenience of the passengers, and the comfort of the coaches has been improved.

A new time-table has been introduced in the Government of the West Coast of Sumatra. This time-table takes into account as much as possible the wishes of the passengers (express communication between Poeloe Ajer and Priaman, improved connexions, new stops, greater frequency of trains).

**Dutch East Indies : Java.** — Passenger traffic : limited transport, remoteness of stations from the centres of population, journey taking too long a time. Goods traffic : unloading and reloading twice, more complicated despatch (way-bill, payment). Improvement measures : the trains were increased in number and speeded up according to the needs.

**Poland : State.** — Causes which have induced passengers to prefer motors to railways : more rapid transport, regular services of more frequent motor buses, stops situated nearer to the centre of towns. Causes which have affected business people : more rapid transport and direct delivery, absence of formalities which inconvenience inexperienced consignors but which are unavoidable on the railways, more adapted to transport in bulk.

To obviate these drawbacks as far as possible we are considering :

1. The establishment of more frequent services, on lines where traffic is light, by means of rail motor coaches.

2. The speeding up of the transport of parcels by means of wagons running non stop between certain stations, and

3. The organisation of a cartage service for the collection and direct delivery of parcels to destination.

**Sweden : State.** — The State Railways and the privately-owned railways have for some years taken important steps to speed up transport and to make it more frequent. Certain trunk lines have been electrified. Several railways of local importance have increased the speed of their trains. Several privately-owned railways have increased their service by means of rail motor coaches.

**Sweden : Stockholm-Roslagen.** — For short distances the transport costs by rail plus the forwarding and cartage expenses are greater than the costs of through transport by motor lorry. The Company has acquired several motor services carrying goods, the competition with which was the keenest. Short-distance traffic has been organised so that the goods can be delivered to the consignee not later than the morning of the day after they were handed in.

**Sweden : Nora-Bergslagen.** — In order to regain lost traffic more frequent communication and faster services have been established.

**Switzerland : Federal.** — The competition of the motor with the railway has been helped by the following circumstances :

a) **Passenger transport.** — The railway, being dependent upon its track, cannot effect transports in every direction like the motor vehicle which has not its own track, and merely takes the most convenient route. Motor transport undertakings (with the exception of the concessioned services) are not, like the railway, bound down to a time-table. The railway cannot make as many stops as the motor vehicle. Finally motor services do not require either costly installations or numerous employees. They are much more independent and much more flexible.

b) **Goods transport.** — The railway cannot transport goods from one house to another without unloading and reloading, and possesses no cartage service in unimportant stations or even stations of moderate importance. Moreover, railway trans-

port, especially when short-distance traffic is involved, often takes longer than transport by motor lorry.

To remedy these drawbacks, we have taken the following steps :

a) **Passenger transport.** — The number and the speed of the trains have been increased, especially on the electrified lines. We have also completed our suburban services and established new halts. Finally, our administration organises excursion trains on various occasions, especially Sundays.

b) **Goods traffic.** — In small and average sized stations, a parcels delivery service has been instituted for trial, the cartage being done by the railway staff.

On the main lines, the despatch of parcels is effected twice daily in both directions in order to hasten transport. With the same object in view, night work or work before and after the usual hours has been introduced in the goods stations attached to the large stations and the hours which the booking office are open have been extended. In addition, an im provement has been made in the time-table of the goods trains by reducing the time for the journeys, the stops in stations, and the shunting in transit stations. In certain cases full wagons are attached to passenger trains. The time elapsing between accepting goods and their despatch on the one hand, and between their arrival and unloading on the other, has also been reduced. Finally the road van service has been improved.

With the object of enabling a better watch to be kept on the effects of motor competition, and to keep it within the limits beyond which, in the interests of national economy, it ought not to go, the Federal Railways formed in 1926 the « Swiss Express Société anonyme » (Sesa), a company which is occupied solely with the relationships between motor and railway, which devotes all its attention to these questions, has gained a vast experience in this sphere, and which thanks to this experience, is in a position to intervene on behalf of the railway, once the necessity makes itself felt. The more the activities of the « Sesa » develop, the more noticeable do its beneficial results for the Swiss railways become. Its first task was to improve, to perfect, and to cheapen the cartage service as regards both delivery to the consignee, and collection from the consignor to the departure station. This task has been accomplished successfully, and the cartage costs have been materially reduced. Another task of this undertaking consists in extending and improving transport between localities not served by the railway. In 1927 three services of this nature were organised, extending over a total length of 95 km. (59 miles).

Although it has only just begun its activities, the « Sesa » has already won back for the railways a large amount of traffic which had passed to the motor. In many other instances it has succeeded in retaining clients for the railway, who were on the point of being lost. The « Sesa » has become a valuable factor in meeting road competition, and its services could scarcely be dispensed with by the Federal Railways.

**Czechoslovakia : State.** — Measures taken with respect to passenger traffic : improvement of the railway time-table and increasing the number of trains by introducing, on lines of secondary importance, rail motor bases and rail motor coaches in place of trains drawn by steam locomotives; with respect to goods traffic: organisation of through goods trains, speeding up the re-consignment of bonded goods, organisation of permanent arrangements for the regular despatch of goods. The rail motor buses in particular have given good results, inasmuch as the working expenses have been appreciably reduced, owing to the simplification of operation both in comparison with the expenses of running rail motor coaches and in comparison with steam traction.

Our rail motor buses are 7-ton vehicles driven by petrol engines, attaining an average speed of 50 km. (31 miles) per hour and enabling a speed of 30 km. (18.6 miles) per hour to be maintained on steep gradients. The vehicle seats 30 persons; the light 5-ton vehicle which is coupled to it, and is provided with a compartment for luggage and express goods, seats the same number of people, so that allowing for adequate standing room, this train replaces the light trains on lines of local importance. At the same time, the combination has the advantage of being able to make a very rapid journey, owing to the brief stops at the halts (no handling of goods, necessary in the case of mixed steam-drawn trains), shorter stops for rolling stock purposes, easier starting and stopping. For all these reasons, the rail motor bus is becoming a means of communication which is able to compete vigourously with the road motor bus, as regards both speed and comfort. Thus on lines where rail motor coaches or buses have been introduced, a considerable increase in the passenger traffic has been remarked, as compared with that when the trains were solely worked by steam.

§ 10. — *What measures have been taken on your railway from the point of view of the rates to diminish motor competition?*

*Please state to what degree a revision of the rates on your lines might in your opinion diminish this competition and if this revision is compatible with the existing regulations for the establishment or the modification of the rates, or if it is not, if it would be possible to make certain change in these regulations and what these changes would be.*

**Denmark : State.** — By the Act of 25 February 1925 the Director General of the Danish State Railways was granted the authority to reduce passenger rates by up to 50 % and the goods rates by up to 33 1/3 per cent in certain special cases in which the tendency of the railways to effect economies renders such a reduction desirable. In accordance with this Act special agreements have subsequently been concluded with the clients of the railway as regards the passenger traffic, and a large number of agreements as regards goods traffic, the object of the said agreements being to acquire or retain the traffic. On 1 April 1927 a general reduction in goods traffic rates took place. This reduction was so considerable that the special agreements lost their value significance. Authority to reduce the rates in special cases still exists, but it is only exercised very rarely, and then only when large consigments are involved.

**Denmark : East Seeland.** — General reduction of the rates, and agreements regarding the prices of transport. These measures have proved efficacious, and this applies to an even greater extent to the speeding up of traffic as well as to the collection and delivery of goods.

**Finland : State.** — The rates of the Finnish State Railways being already very moderate, any alteration of these rates does not appear to us capable of diminishing the competition in question, and we have no intention of modifying our rates for this purpose.

**Greece : State.** — We have put into force several exceptional rates. We do not believe that a fundamental revision of our rates would have any great effect on motor competition.

**Norway : State.** — On 15 October 1927 we modified our system of rates applying to consignments which do not form full loads, with the object of enabling it to meet the competition on short journeys. The rates were reduced and the rating based on the value of the goods was abandoned in favour of specific rating. As a result, the transport of parcels previously

subject to very high charges (namely, those containing very valuable products) and which were covered by the motor services, became less expensive than before. As regards passenger traffic, the price of single tickets, especially for short journeys, was reduced on 1 April 1927.

**Holland : Netherlands State.** — Reduction of certain rates, agreements with the consignors for the transport of large quantities of goods.

**Dutch East Indies : Sumatra.** — For the transport on certain lines, various kinds of goods were placed in a lower class of rates. All the goods rates, as well as the 2nd class passenger fares, were reduced on certain lines subject to competition. On some trains, a special rate, lower than the ordinary rate, has been introduced for passengers.

**Dutch East Indies : Java.** — The 1921 rates for 1st class, 2nd class, 3rd class, 3rd class natives.

| | | | | |
|---|---|---|---|---|
| In Dutch cents per passenger and per kilometre. . . . . . | 8 | 4 | 2 | 1.4 |
| (In gold centimes . . | 16.6 | 8.3 | 4.2 | 2.9) |
| Were reduced in 1927 to, in cents,. . . . | 4 1/2 | 3 | 1 1/2 | 1 |
| (In gold centimes . . | 9.4 | 6.2 | 3.1 | 2.1) |

The last rates are applied on all lines except those where there is no motor competition, and where the 1921 rates have remained in force. The reduction in the number of 1st class passengers has only been affected to a slight extent by the rates. Most of the class of persons, who may be considered as travelling 1st class, possess their own cars. With some reservations, the same may be said of the class of persons, who come into consideration as travelling 2nd class. It is expected that the 1927 rate will prevent the reduction in 3rd class native passengers. It has not been considered necessary to introduce alterations in the fixed rate.

**Poland : State.** — No measures affecting the rates have been taken on our system to meet motor competition, this competition resulting not from the price of transport, much lower by rail than by road, but owing to other special advantages which the motor services can guarantee for their clients.

**Sweden : State.** — After the Great War the rates were reduced several times. The rates for short distance transport were reduced at the same time also on account of the motor competition. In addition to general reductions for journeys of 1 to 100 km. (0.62 to 62 miles) a large number of alterations have also been made as regards passengers and for goods in small parcels.

**Sweden : Stockholm-Roslagen.** — A single rate is applied for the transport of small goods over short distances from 50 to 100 km.

**Sweden : Nora-Bergslagen.** — Reductions have been made in the price of tickets in certain connexions, in return tickets (50 %), in Saturday tickets (80 %), and in collective tickets (100 %). The goods rates has been reduced from 32 to 58 % between certain stations where the motors have captured much of the traffic.

**Switzerland : Federal.** — After being authorised to do so by the Federal Department of Railways, the Federal Railways and a large number of private transport undertakings decided to transport, after 1 April 1927 and until further notice to the contrary, in the form of internal service and reciprocal through service, goods of all kinds, by express and slow trains, at rates (cartage and other charges included) corresponding to the price of transport under reasonable conditions by motor lorry, provided that :

a) the consignor produces on demand of the railway administration documents proving that, without this concession in the rates, it is more profitable for him to transport the goods in question by motor

lorry, and that, moreover, he is in a position to do so;

b) the rates so conceded leave to the railway administrations, in addition to the cost, as determined by them, a profit proportionate to the undertaking;

c) the consignor agrees to have transported annually by rail a minimum quantity of goods, the amount of which is to be fixed in each case;

d) the consignor agrees to dispense entirely, or to an extent to be agreed upon in each case, with the use of motor lorries.

As far as they are concerned, the Federal Railways have empowered the « Sesa » to negotiate with consignors concerning their fulfilment of the above-mentioned conditions, and the charges to be made to them. These negotiations are subject to the legal principle that no privilege may be granted under any form which, in the same conditions, is not accessible to everybody.

In addition, the possibility is being considered of reducing the railway charges generally, once the financial situation of the Federal Railways will allow of it, and it is hoped that it will be possible for this measure, at least in so far as concerns the highest classes of rate, to come into force on 1 July 1929. The revision of the railway rate regulations appears, moreover, to be necessary. The obligation of carriage, imposed by the State on the railways, interferes in a very serious manner with the organisation of transport. It has not been included, in the existing legislation because, when the Act was elaborated, the railways held a real « de facto » monopoly. As the motor lorry traffic increases in importance, however, this monopoly, of which the obligation of carriage was a consequence, tends to disappear, and the obligation, to which there is no longer any corresponding law, becomes an unfair burden. The least that the railways can request is a reasonable mitigation of this obligation, and of the necessity, to which they are subject, of observing fixed rates. The Federal Department of Railways is actively engaged with the revision of the law on transports, which dates from 1893, and of the corresponding regulations. The preparatory work concerning this revision will very soon be completed.

In this connexion, we should like to point out that a member of our Council of Administration has introduced a motion in Parliament intended to protect the Federal Railways and private railways against motor competition. By this motion, the Federal Council are invited to prepare legislative acts which will subject the transport of passengers, goods, and animals by motor vehicles to conditions similar to those which the present Federal legislation imposes on railway transport.

The Federal Council have not only declared their willingness to examine this motion, but have already stated in broad outline the manner in which they intend to proceed with the matter. In the view of the Government it is essential that motor traffic and rail traffic should be placed on approximately the same footing from the legal standpoint. First and foremost comes the question of regulating the hours of work of chauffeurs of trade vehicles, and after that there are certain obligations of the railway (obligation of carriage, strict observation of the rates) to be mitigated.

**Czechoslovakia : State.** — We are introducing provisional reductions in the rates on certain lines particularly menaced by road competition, or by arrangement with the interested parties whom we persuaded individually, by allowing rebates depending upon definitely fixed quantities to return to the railway. We are not considering any great reduction in the near future in the rates for short distance traffic.

§ 11. — *To what causes other than those considered in paragraph 9 and 10 do you attribute motor transport competition and what measures have you taken*

*or could you in your opinion, take to attenuate these causes?*

*Please state the measures which you have taken or are considering taking to maintain the struggle against the competition of the regular motor services or of the free or private motor traffic, the degree of efficacy of these measures and the conditions necessary to augment this efficacy.*

**Denmark : State.** — The very large number of private motor cars in our country has materially contributed in reducing the use of railways by the well-to-do. It is scarcely possible to take any effective steps against this reduction. Apart from the steps enumerated in the reply to question 9 and considering the present regulations of our country relating to the traffic of regular motor services, it is not possible to indicate any better means of reducing the competition.

**Denmark : East Seeland.** — Publicity among the producers and merchants by means of agents.

**Finland.** — See reply to question 9.

**Norway : State.** — See reply to question 14.

**Holland : Netherlands State.** — See reply to question 12.

**Poland : State.** — To reduce the causes of motor transport competition, we consider it expedient to lend our full support to the construction of private sidings, connecting the clients premises with the railway.

**Sweden : Nora-Bergslagen.** — The proprietors of motor services fix their rates without due consideration of the upkeep expenses and depreciation of their vehicles. At the largest motor service stations, they offer to transport goods to destination at very low prices, sometimes even gratuitously.

**Switzerland : Federal.** — The use of motor vehicles enables business houses and industrial firms to serve their clients directly and rapidly. Goods may be deposited directly into the warehouses, cellars, or lofts, and the client may be saved a good deal of detail work. The suppliers' employee opens cases, places barrels in position, and if need be, notes complaints and receives fresh orders. Since the manufacturer or wholesale dealer delivers the goods directly, the retailers have no longer any need to keep large stocks, and can manage on a smaller capital. When transport is effected by motor lorry, there is no need for reloading, and in many instances, packing or at least very careful packing may be dispensed with. Owing to direct delivery, damage is also less frequent.

The hours of work and the holidays of the chauffeurs of the firms in question are not regulated by law while, for the large majority of the railway employees, an 8-hours' day and holidays of up to 3 or 4 weeks are laid down by law.

The owner of the motor vehicle is not bound to charge any particular rate, he fixes the prices as he thinks fit in each case. He can always arrange to make a profit, seeing that he is not obliged to effect transport, while the railway, being under this obligation, has to effect not only the transports which bring a profit, but also those which entail losses. Once its rates are fixed the railway cannot allow itself to be prompted solely by economic considerations of a private nature, but must also take into account the needs of public economy.

The owner of a motor vehicle is not subject to any legal civil liability as extensive as that of the railway, and is subject to no technical control whatever.

The railway is obliged to pay to the State millions of francs in the form of stamp duties, while the motor transport undertakings escape, for the same transport, all contributions of this nature.

The railway has to construct its own road, while the owner of a motor vehicle, it is true, is subject to a tax on motor

vehicles, but this tax, far from representing the sums indispensible for the upkeep of the roads, is not even sufficient to cover the additional expenses due to the fact that motor vehicles wear the road much more quickly than the other means of locomotion.

§ 12. —*Have you undertaken to work regular motor services as an additional enterprise of your railway? How has this enterprise been organised and what have been the results ?*

*Please state :* a) *what sort of motor services form this enterprise, especially if they are services between places joined by the railway or services whose only connexion with the railway is that they act as feeders; and* b) *what is the length, the passenger and goods traffic, and the economic results to your railway of working such services?*

**Denmark : State.** — No.

**Denmark : East Seeland.** — We have instituted as auxiliary undertakings to our administration 20 regular motor services which run in conjunction with our railway as extensions. The financial results are good and show that by this means goods traffic may be kept to the railway.

**Finland : State.** — No.

**Greece : State.** — We are considering the organisation of two regular motor services as a supplementary undertaking to our railway : one of 20 km. (12.4 miles) connecting two localities served by the railway, and another of 50 km. (31 miles) connected to the railway alone.

**Norway : State.** — Quite recently, the Norwegian State Railways began, with the approval of Parliament, to run in some districts regular motor services for passenger transport. Certain private Norwegian railway companies are also the concessionnaires of motor services, operated by themselves. The regular motor services of the Norwegian State Railways have a total length of 47 km. (29.2 miles). They serve they same regions as the railways which they complete on the routes concerned. No statistics have been compiled regarding the activities of these services.

**Holland : Netherlands State.** — About a year ago our Companies founded a limited liability company to operate regular motor services for passenger and goods traffic. This company forms an independent undertaking but our Companies have provided the necessary capital. It may be regarded, therefore, as an auxiliary undertaking to our Administration, with which it is intended to co-operate.

The undertaking is still in the preparatory stage. Its chief aim is to link the passenger and goods traffic with the railway by rapid communication and at the price of competing transport. Its services will in the first place collect the traffic and feed it to the railway, but they will also serve local traffic between near lying places. In addition, it is intended that the undertaking should handle railway traffic, which owing to the new situation, may be effected more profitably by motor than by rail. In addition, the undertaking will equip garages and parking places for private cars near the stations in large towns, thus facilitating the traffic of motor-owning passengers. It will make efforts to regain the special traffics that have been lost to the motor services, for instance, the carriage of fish from the sea ports to towns within a certain radius. Its principal aim being to serve the railways, it will be able to adjust its rates in co-operation with those of the railway in such a way that the transport costs for a combined journey by road and rail will be lower than those of competing services.

Up to the present, the cartage of goods in most of the towns of any size, and the management and administration of a large portion of our express goods traffic (carriage of parcels) was in the hands of one private company with whom we had a

contract. Thanks to this, our new subsidiary will be able to take over the whole of this undertaking with its plant and staff, which will be absorbed in it. This state of affairs will enable us to facilitate cartage, to reduce expenses (which are fairly high at present) to the benefit of our traffic and to extend the delivery radius round the railway stations.

**Dutch East Indies : Sumatra.** — Yes. See replies to questions 1, 2 and 5a.

Figures for transport during 1927 (see table below).

| — | Motor services of the State Tramways of the South of Sumatra. | | Motor services of the State Railways of the West Coast of Sumatra. | |
|---|---|---|---|---|
| Number of passengers | 36·403 | | 115 588 | |
| Distance travelled by passengers, kilometres (*miles*) | 1 694 454 (1 052 904) | | 3 731 120, (2 318 452) | not including passengers carried by supplementary motor lorries. |
| Number of metric (*English*) tons of goods | 16 382 | (16 120) | 5 496 | (5 408) |
| Number of tonne-kilometres (of *English ton-miles*) of goods | 1 174 817 (718 480) | | 453 082, (277 090) | not including the tonne-km. of goods carried by supplementary motor lorries. |
| | Florins | Gold-francs | Florins | Gold-francs |
| Passenger receipts | 72 191 | (150 157) | 116 515 | (242 351) |
| Goods — | 419 240 | (872 019) | 246 302 | (512 308) |
| Various — | 8 993 | (18 705) | 4 174 | (8 682) |
| Total receipts | 500 424 | (1 040 882) | 366 991 | (763 341) |
| Working expenses | 501 250 | (1 426 000) | 293 093 | (609 633) not including rent, depreciation, pensions, general management expenses, and road tax. |
| Surplus | 826 | (1 718) | 73 898 | (153 708) |

The deficit in the operation of the motor services of the State Tramways of the South of Sumatra, was made up by the corresponding railway receipts.

There are no State motor services in operation on routes forming part of the State railways (tramways).

**Dutch East Indies : Java.** — Our company in the first place operated its own motor service, which however ran at a

loss and for that reason was abandoned. Later it was decided to undertake the operation of a motor service in collaboration with a third party, but on examination of the receipts and expenses it was found that, from the financial standpoint, favourable results could not be expected, so that the matter was not proceeded with.

**Poland : State.** — Provision has been made in the budget of 1929 for the organisation of regular motor services as an auxiliary undertaking of the Polish railways.

**Yugoslavia : State.** — No.

**Sweden : State.** — The State Railways have organised four regular motor services in the Bohuslän province, with a total length of 142 km. (88.2 miles). In 1927, 54 000 passengers and 3 000 metric (2 952 English) tons were carried. The receipts amounted to 157 000 kronor (218 000 gold francs) and the expenditure to 141 000 kronor (195 800 gold francs) which includes the depreciation but not the interest on the capital involved. These services form branch lines of the railway, and the latter has gained thereby an appreciable amount of traffic.

Various private railways have also organised regular motor services.

**Sweden : Stockholm-Roslagen.** — Yes, all the competitive motor bus services are at present in the hands of the railway company.

**Sweden : Nora-Bergslagen.** — No.

**Switzerland : Federal.** — In the Surb valley, a motor service for the transport of passengers and goods has been organised to take the place of the railway originally projected. The passenger service is worked by the Federal Administration of Posts and the goods service by the « Sesa ». This motor service is 25 km. (16.5 miles) long, and has only been in operation since the autumn of 1927.

**Czechoslovakia : State.** — The competition of road motor services having become serious for the Czechoslovakian State Railways, their administration has decided to organise as a trial motor services on the routes where competition is making itself particularly felt, principally on the routes: 1) Pardubice-Chrudim (13.5 km. [8.4 miles]); 2) Uzhorod-Mukaceva (45.1 km. [28.0 miles], Mukaceva-Berehevo (28.9 km. [17.9 miles]).

Route 1) runs parallel to the railway Nem. Brod-Pardubice. It has been opened up for service because it was not possible to satisfy, except at a considerable first expense, the transport requirements of the region. It is served by five double motor bus journeys daily. Route 2) runs in a transverse direction, and links up localities having considerable business relations between which the railway makes a wide detour involving two changes. This route is served from Uzhorod to Mukacevo by five double motor bus journeys daily, and from Mukacevo to Berehovo by three double motor bus journeys daily. These two services are for passenger traffic solely, and for parcels of a limited weight [maximum weight of 30 kgr. (66 lb) per package].

The operation of these two motor bus services has not involved the organisation of any special office. The administration and the commercial traffic are in the hands of the station-master at the two termini of the bus routes. As regards the vehicles, the nearest locomotive depôt has instructions to attend to it. In addition to the regular journeys, the motor buses may be run as required for special journeys.

The basic rate is 0.5 Kc. (7.7 gold-centimes) per person and per kilometre (12.4 gold-c. per passenger-mile).

These two motor services have been operating only from January to March 1928 so that as yet we have no information as to the economic results of running them.

No goods are carried. This is of no consequence for the service on route 1) because we possess a parallel railway. As for the service on route 2), it is probable that we shall gradually proceed to the transport of goods with the object of speeding up delivery, and in order to save the expenses of handling, warehousing, and of the double unloading and reloading.

During the current year, the motor bus passenger traffic of the railways will be extended to other routes.

§ 13. — *Have you organised on your railway a mixed service of direct railway transport and regular motor services, and what are the principles upon which such an enterprise is organised?*

*Please state the agreements made with the concession holders of regular motor services which enable the direct transport of goods to be carried out and the direct journeys of passengers with or without a choice of route by rail or road.*

**Denmark : State.** — No.

**Finland : State.** — No.

**Greece : State.** — No.

**Norway : State.** — The Railways have made agreements with some regular motor services for the through transport of goods. This concerns the delivery of goods which have arrived at the railway station and vice versa. The regulations relating to these transports have been drawn up in a very simple manner.

**Holland : Netherlands State.** — No.

**Dutch East Indies : Sumatra.** — In various districts of the system of the State Tramways of the South of Sumatra, goods are collected and delivered to destination, in collaboration with privately-owned motor services. Consequently part of the traffic, formerly carried out entirely by motor, has again returned to the railway. A privately-owned motor service was formed in the same way between Hadjipemanggilan and Soekadana under the auspices of the State Railways. A private motor transport undertaking, having agreed to attend to the service between Martapoura and Mouara Douwa, the direct operation of the service on this route by the Government was transferred to the above-mentioned undertaking under the auspices of the Government, the consignors retaining the facility of through transport between the places of despatch and destination.

This system of special through rates has been in force since 1925 for the transport of goods by the State Tramways of the South of Sumatra, and the contiguous motor services operated by the State.

New regulations have been drawn up for the transport of goods by through traffic between the State Railways of the West Coast of Sumatra, the State motor services, and the Deli Railway Company.

According to the agreements, a certain part of the transport charges (corresponding to the expenses of transport as far as the railway) is allotted to the privately-owned motor undertakings, while the State Railways themselves are satisfied as a rule with a more or less reduced rate.

The steps taken by the State Railways, such as fixed rates and facilities of through goods transport, and of through passenger journeys, ensure a sufficient profit to the co-operating motor transport undertakings — without the grant of supplementary subsidies by the railways to the above-mentioned undertakings.

**Dutch East Indies : Java.** — Arrangements have been made, as regards some towns and villages, with the concessionnaires of regular motor services to allow through goods transport, the transit of goods, through journeys for passengers, and the direct forwarding of parcels.

**Poland : State.** — The inauguration of mixed services of through transport by rail and by regular motor services, and of

combined tickets and way-bills is being considered in connexion with the organisation of regular motor services as a supplementary undertaking of the railways (see reply to question 12).

**Yugoslavia : State.** — No.

**Sweden : State.** — In some cases, agreements have been concluded with regular motor services regarding the through despatch of goods by rail and motor.

**Sweden : Stockholm-Roslagen.** — No.

**Sweden : Nora Bergslagen.** — No.

**Switzerland : Federal.** — A scale of charges was published in 1925, providing for the through despatch of luggage and express parcels between the railway stations and various stations of the motor services operated by the Administration of Posts.

**Czechoslovakia : State.** — Mixed services for the through transport of goods by railways and private motor bus services have not yet been organised here. Such a mode of transport is projected, however, on the route Kosice-Roznava (71 km. [44.1 miles]) in South-East Slovakia. These two localities are inaccessible by rail except by a wide detour (488 km. [303 miles]), taking the Vrutky-Plesivec line. The passenger, luggage, and goods traffic between these two places has been conceded to private motor bus services. We are just now negotiating with respect to the conditions under which these companies would agree to take part in the through transport of goods. The question of goods traffic by our own motor buses has not yet passed the preliminary stage.

§ 14. — *What other means have you made use of to avoid or to diminish on the one hand the effects of road competition on the traffic of your railway, and on the other, to contribute to the development of motor services as feeders ?*

**Denmark : East Seeland.** — Prompt and careful despatch. Obligingness of railway employees towards the public.

**Norway : State.** — The Minister of Public Works has decided that the applications for the concession of regular motor services must be submitted to the opinion of the State Railway Company, before approval by the Department of Bridges and Roads. In addition, by virtue of an Act of 1926, the Minister of Public Works may cancel the concession of a regular motor service or may modify the conditions of its operations, if such a measure is necessary to protect the other public means of communication. As regards the above-mentioned provision laying down the cancellation of the concessions of regular motor services, or a revision of the same, the Minister of Public Works emphasized in his statement at the Storthing on the 13 May 1927, that in a large number of cases, it will be difficult for him to apply this provision because the law seriously limits its application partly on account of the fact that the provision, being applied when the service is already in operation, it too late effectively to prevent competition.

The question of the competition between road and rail transport has been studied by an official commission which has just sent in its report. The majority of the members of this commission state that the question of competition should be settled as follows :

If the matter concerns regions unprovided with railways or branches of existing railway lines the concession of regular motor services should be granted under the ordinary conditions to any person capable of ensuring satisfactory operation. If, on the other hand, the matter concerns regions already provided with railways, the concession of regular motor services should only be granted on condition that these services form a natural branch of the system of communication, or that they supplement the railway. If these conditions are satisfied in such a manner that

the activities of the railway and the motor service mutually complete each other, the two organisations should, according to the circumstances, either work independently of one another, from the financial standpoint, or collaborate, either by the railway itself organising the motor service or by the grant of a concession for operating the motor service to a private company or to a group, according to the regulations laid down, to be placed under the obligation of collaborating with the railways. The majority of the members of this commission also suggest that a special authorisation should be required to transport passengers or goods by motor (hire service) if the route in question extends over several communes, even if it is not a question of regular services. The effect of this regulation would naturally be to meet the serious competition of vehicles hired occasionally.

It is difficult to say at present if the public authorities will adopt these regulations, either wholly or in part.

**Switzerland : Federal.** — The cantons have been compelled, owing to the considerable development of the motor traffic and the resulting excessive wear and tear of the roads, to impose certain restrictions on this traffic, namely, limitation to 10 tons of the weight of a fully loaded vehicle, and to 12 tons of the weight of a train of motor vehicles.

The Berne Canton has issued a special decree to regulate the motor traffic on its territory. This decree constitutes an innovation in this sphere in the sense that it embodies strict provisions intended not only to guarantee the safety of the traffic, but also to save the roads. It also prohibits, **inter alia,** motor lorry traffic during certain hours of the night.

[ 385. (01 ]

# REPORT No. 3

(Belgium, France, Holland, Portugal, Spain and their Colonies)

## ON THE QUESTION OF PENETRATION RAILWAYS (SUBJECT XVII FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION (1) (2),

By Pierre JOURDAIN,

MANAGING DIRECTOR OF THE NORTH-EASTERN SECONDARY RAILWAYS OF FRANCE.

Figs. 1 to 15, pp. 2933 to 2964.

Question XVII, upon which we have to report in so far as concerns Belgium, France, Holland, Portugal and Spain comprises two distinct sections :

— the construction of penetration railways in new countries;

— the construction of feeder railways in all countries.

Ninety companies or organisations have been consulted upon these two questions; only thirty-three have given us information of which we have been able to make use : fifteen for the first section and eighteen for the second. Consequently, the result of our inquiries has not that amplitude which would have been desirable in considering a question of so general a nature.

From the replies received we have none the less endeavoured to arrive at certain general conclusions.

We considered that the task alloted to us covered three main points :

— what are the principles which have determined the construction of these railways?

— what are the conditions under which they are at present being operated?

— what appear to be their future prospects?

Our questionnaire was drawn up in complete agreement with Mr. Mellini, with whom we had the opportunity of conferring on the matter. We were unable to have more than an exchange of correspondance with Sir Ashley Biggs and Mr. Lloyd Jones, and it may be, therefore, that the form of their report differs somewhat from that contemplated by Mr. Mellini and ourselves.

## CHAPTER I.

### Penetration railways.

#### 1. General conditions.

Our first endeavour, in considering the first section of the question, was to discover what are the principles which it appears necessary to adopt at the present day in studying the problem of railway construction in a new country.

The development of motor traction during the last few years has in fact been such as to modify the principles formerly adopted in this connection, and the ques-

(1) This question runs as follows : « Penetration railways. Construction : *a*) Penetration railways in new countries; *b*) Feeder railways in all countries. »

(2) Translated from the French.

tion arises as to whether, in a very large number of cases, that system of traction should not be utilised, at all events for the purpose of ascertaining a country's traffic potentialities and as an initial means of penetration.

In certain countries use has been made from the beginning of light railways, which can be rapidly constructed. Is this practice to be recommended, apart from military considerations?

This part of our inquiry formed the subject of the first four questions: It appears to us essential to set out in full the views of a number of companies which have for a long time been operating penetration railways; their experience should prove most valuable as a basis for discussion.

The *Belgian Upper Congo to the Great African Lakes Railway Company* expresses the following views on this first question :

The primary function of railways in new countries must be to assist in developing the land with a view to the exportation of the local products.

As a general rule it is this class of transport which has to be provided for at the commencement to the exclusion of passenger transport, which is not of primary importance, and of import transport, which only begins to affect the railway to any appreciable extent when local industries have attained a certain development.

It is certain that the motor route must be contemplated as the means of testing the future traffic possibilities, but it must be remembered that the cost of motor transport is extremely high and, in the Belgian Congo, particularly in the Upper Uelé region, it ranges from 8 to 12 francs per ton-kilometre (13 to 19.6 fr. per Engl. ton-mile). This, for instance, renders impossible the transport by road of food stuffs intended for export.

This means of transport can only be used for the relatively more expensive products, such as coffee, cotton, etc., to the exclusion of foodstuffs for the natives, such as haricot beans, peas, flour, etc.

From the point of view of passenger traffic the motor route is certainly advantageous, as it can be run profitably.

We consider it preferable, however little a country may be susceptible of development (*i. e.* from the point of view of the suitability of the soil for crops and the available supply of native labour), to rely at the outset on light railways, which can be rapidly constructed.

*Algerian State.*

In the Sahara regions the nature of the soil and the climate will always present insuperable obstacles to the construction of good roads. It will be necessary to be content with tracks, and these will not permit of any extensive development of motor transport. Nevertheless, it would appear that the organisation of a system of tracks for motor traffic must precede the railway, and that the question of the desirability or otherwise of subsequently constructing railways must be determined in the light of the knowledge acquired in the operating of the motor trafic.

*West Africa.*

The object of a penetration railway is to link up with the seacoast some rich and populous region in the interior of a country, so as to stimulate and develop imports and exports.

The rich and populous region having been clearly defined after careful preliminary study of its economic conditions, the next step will be to determine the starting point of the railway, which must be that point on the coast at which maritime access is easiest and safest.

Undue influence must not be exercised by port installations which may al-

ready exist at a point which does not fulfil the preceding conditions. The route of the railway will be determined by the neccessity of serving all the rich and populous zones which are to be found between the harbour station and the inland terminus.

Wherever adequate and economic roads can be constructed, the automobile must precede the railway.

When it has been decided to construct a railway, the policy of laying a light track in the first case and later converting it into a heavy track should be avoided; the rail which is finally to be adopted should be laid from the beginning, as this practice generally entails less labour and less time.

As soon as traffic has attained a certain intensity in a given country, the railway will be preferred to the road. The cost of maintenance of roads which are used by a large number of heavy vehicles is a heavy burden for the generally scanty population of any new country, and this burden may tend to diminish production. The maintenance of a railway, when once well established, entails the employment of much less labour.

*Railways of the Ivory Coast.*

The general and local economic guiding lines result from a general plan. Il appears essential, however, that before a railway is constructed full consideration should be given to the conditions affecting the manner in which it must be linked up with existing lines or with lines which may have to be constructed in the more or less distant future. The dead-end lines which serve important centres of internal traffic are only a temporary expedient, and the method of their possible future extension from either end must be carefully studied and determined in advance. Where a line is to be constructed, the initial capital expenditure must be determined in relation to the cost of concessions and the estimated future working expenses.

Undue importance should not be attached to great rapidity of construction; in any case, the difficulties attending the employment and training of native labour are against this.

The motor appears to be decidedly superior to the light railway, especially when the road system gives it free access to the points of production.

*French Dahomey Railway Company.*

In general the decision as to the opening up of a railway in a colony rests with the Governor-General, and this decision is generally based not on purely traffic considerations but on the necessity of serving some isolated region.

The first colonial lines have all been strategic in origin and in many cases have been constructed by army engineers.

Once these penetration lines have been constructed, the construction of subsequent lines depends upon the traffic which has developed along the penetration lines, and the rules to be observed in considering such extensions then become similar to those adopted in the older countries. Obviously, of course, any estimate of probable traffic can only be very tentative and no *a priori* formula can be used in making such estimates.

The method usually adopted is to make a careful investigation into the resources of the regions to be served, gathering information in regard to the existing native markets and existing forms of cultivation, and then to assume that an appreciable increase in trade and cultivation will follow the provision of a railway line. In the colonies one may without fear be optimistic when estimating the increased economic activity which will follow the introduction of a railway service into new regions.

Political considerations, of course, enter into any project for the construc-

tion of a new line to serve any given regions.

Finally, in the colonies it is the advent of the railway which causes native villages to be formed and gives a stimulus to the cultivation of the regions through which it runs.

We will quote one particular example: On our line a section of about 100 km. (62 miles) had remained uncultivated because it consisted entirely of forest land. When during the war we were compelled to use wood for fuel, we did a large amount of tree-felling in this region, and immediately the natives, who had hitherto shirked the work of felling on their own account, began to use the clearings in the forests for the cultivation of maize, yams, tapioca, etc.

We consider that in new countries the railway continues to be, as in the past, the only effective and rapid means of extending the path of civilisation.

At the present day numerous roads are constructed, and this leads to the introduction of motor services which serve as extensions and lateral feeders to the railways. These services, however, are very costly, and it is found that they always have to give place to the railway when budgetary conditions permit of the latter.

All the motor services in operation in Dahomey are running at a loss, whereas the railways show quite reasonable profits.

We do not consider it advisable, as regards the main penetration lines, to make use at the beginning of rapidly constructed light railways, and in this connection the experience of the Belgian Congo may be borne in mind.

In our opinion the consideration which should be preponderant as regards the construction of a railway — apart from political and military considerations — is that it should be made to serve the centres of population, for, wherever labour is abundant, one can count with certainty on a rapid development in cultvation and in the exploitation of the country's natural ressources in general.

*Netherlands State Railways.*

When contemplating the construction of railways at the public expense in the colonies, account must be taken of the economic advantages which such facilities will bring. Account must also be taken of the indirect advantages, even through these cannot be expressed in figures. The first step is to ascertain definitely that the construction of the new line will result in lower costs of transport than those which the community has to pay with the existing means of transport or would have to pay if those means were merely improved. Among the costs must be included not only actual working expenses, but also interest charges and the cost of renewal of rolling stock.

If the existing means of transport are insignificant, it is necessary to consider whether by other means, and in particular by the construction of ordinary roads, it would not be possible to arrive at lower transport costs (calculated on the basis indicated above) than those which would apply in the event of a railway being constructed.

The projected railway must be capable of subsequent extension if it is eventually to be remunerative. It is not possible to count upon profits right from the beginning.

The automobile constitutes a very suitable means of transport, and may in many cases be made to serve as a means of penetration — by the construction of roads during the period when motor transport is more economic for the community than transport by railways run by the State.

In consequence of the gradual development of a system of motor roads, and in view of the amount of capital invested

in the construction of the roads, it may however happen that the construction of a railway is retarded, even when it may have become economically desirable to substitute rail transport for the existing system of transport.

Temporary narrow gauge penetration lines have not so far been built, although in certain circumstances it is conceivable that they might be with advantage. The disavantage of such lines lies in the fact that where there is a large increase in traffic, there is a tendency to continue to effect improvements in the lines, thereby sinking more and more capital in them, with the result that the prospect of losing the capital invested — a loss which is to be anticipated when it is a question of intalling a permanent line — acts as an inducement to postpone the construction of new lines, in some case until long after their construction has become desirable.

The factor which weighs in favour of the construction of a railway is that there is a large quantity of merchandise to be transported, the transportation of which, in the absence of a railway, is either not possible or possible only under uneconomic conditions.

*Portuguese Railways.*

As the railway is the principal instrument of penetration and economic development in a new country, this factor must be taken into account when considering its planning and construction : it must be made to serve regions which abound in natural resources (animal, vegetable or mineral) and regions which by reason of their climatic conditions are most likely to experinece an increase in population and to favour its permanent settlement along the railway routes.

A country in process of formation will find in a well planned system of roads its principal means of economic progress. Motor transport consequently takes the first place in the movement of native products, since it gives them access to centres of population or to ports or to any railways which may exist. For a long time, therefore, and indeed for so long as it is not possible to extend the railway system of the country, motor services will be necessary for testing traffic potentialities in regions distant from the railway, and will thus serve as useful instruments of economic penetration, while at the same time affording useful data for arriving at an approximate estimate of the prospects of any railway, the construction of which may be under consideration.

Experience has shown that light railways of rapid construction are not to be recommended. They should not be adopted unless, when constructing them, provision is made for their widening within a relatively short space of time if the development of the country's trade renders this necessary. Further, the present tendency is to replace them by motor transport, even where such railways already exist.

In constructing railways account must be taken of the nature of the soil and sub-soil of the regions to be traversed and, in the case of colonial railways, of the suitability of the regions for the settlement of Europeans. We have already made this observation in reply to the first question.

*Thiès to the Niger Railways.*

In a new country a penetration railway is always, at the beginning, an important means of pacification and of establishing a firm footing in the regions served. Traffic conditions do not carry much weight in the original plan. These conditions are developed by the coming of the railway whereby life is brought into the country and frequently its settlement.

The traffic investigation of a region by motor services demands the creation of

serviceable roads. This method may, indeed, serve to ascertain the traffic requirements of the moment, if these are not already known, but it is to be doubted whether it possesses in the same degree as the railway that character of permanency which is necessary for creating a current of human activity along its path.

*Tunisian Railway Company.*

The lines constructed in the early days for the exploitation of the Regency became in a relatively short space of time wholly inadequate for traffic requirements. We have been compelled to reconstruct lines and viaducts at great expense, and to relocate sections in order to avoid steep gradients. For this reason we consider that in a new country the policy should be to lay down from the beginning a railway system adequate for both fast passenger trains and heavy goods traffic. In view of the facilities afforded by motor transport, it no longer appears necessary to provide branch lines or sections of line specially to serve isolated districts. The first consideration must be to provide facilities for heavy and long distance traffic.

When the French Protectorate was established in 1881, the only good carriage road in Tunis was the 4 km. (2.5 miles) between Le Bardo and the town of Tunis. The whole of the land transport passed over what were nothing more than mere tracks; there were no bridges over the rivers, and in the rainy season the tracks became impassable.

In 1881 Tunis already possessed the following railway lines : Tunis-La Goulette-Marsa-Le Bardo, 34 km. (21 miles) constructed under a concession granted in 1871; Tunis-Souk El Arba, under a concession dated 1876, and its continuation to Ghardimaou on the Algerian frontier, 187 km. (116 miles) constructed under a concession granted in 1877; Marine Tunis, 1 km. (0.6 mile); and Tunis-Hamman-Lif, 16 km. (10 miles).

Railway penetration in Tunis was important, apart from political considerations, from the point of view of the transport of mineral products. There were minerals of all kinds to be brought to the ports (phosphates, iron, lead, zinc) — substances which lend themselves admirably to transport by rail, but which it would have been difficult to transport by road in view of the great quantities to be dealt with and the disance between the mines and the ports.

In the year 1927 we carried :

| | |
|---|---|
| Phosphates . . . | 747 113 tons |
| Mineral ores . . . | 932 703 tons |

We consider that penetration in Tunis, even at the present day, should continue to be by means of railways, and that motor transport, even with the gradual development of motor roads, can only be used within a very restricted area and for carrying goods between the railway stations and localities which are not served by the railway.

There can be scarcely any arguments in favour of a line of 0.60-m. (1 ft. 11 5/8 in.) gauge, and the minimum gauge permissible would appear to be 1 m. (3 ft. 3 3/8 in.). Our metre gauge lines, with 25-kgr. (50.4 lb. per yard) rails, have already proved inadequate and we are having to reinforce them.

In the case of a country such as Tunis was in the past, i. e. without roads, without navigable rivers and with the prospect of having to provide for heavy transport over long distances, we consider that the railway constitutes the only practical method of productive penetration.

* * *

It will be seen that the opinions expressed above upon these general questions vary somewhat, and it is for this reason that we have considered it advisable to reproduce them almost in full.

The discussion which is to take place

at Madrid will perhaps succeed in crystallizing certain definite principles which appear to emerge as a result of our inquiries.

The use in the first place of narrow gauge railways seems to have little to recommend it. The motor road may in many cases be an excellent method of reconnoitring a country. The first consideration which should influence a decision as to the creation of a railway must be goods traffic requirements. In certain regions of Africa, however, it would appear that the question of population is of primary importance, as an essential condition of the development of the country is a supply of native labour, which must be sought and brought to the various centres of employment.

In general it would appear that in many cases blunders have been made owing to insufficient preliminary study of a country and its resources; these experiences should serve as warning for the future, and every day sees a diminution in the unexplored areas, of the resources of which we have still inadequate knowledge.

### 2. General technical considerations.

In the next place we have endeavoured to learn, by means of Questions 5, 6 and 7, by what considerations railway administrations have been guided in their choice of gauge; and one is struck by the diversity of gauge adopted, for example in Africa : 0.60 m., 1 m:, 1.055 m., 1.067 m. and 1.440 m. (1 ft. 11 5/8 in., 3 ft. 3 3/8 in., 3 ft. 6 in. and 4 ft. 8 3/4 in.) whereas the policy of the railways of Central Europe has been to adopt a uniform gauge, the exceptions to this rule being Russia and Spain, in whose cases different gauges were adopted purely for reasons of military protection. It does not appear that in the early days much importance was attached to providing for possible future linking up of the original penetration lines in the Dark Continent, but the respective Governments and railway administrations were not long in realising the importance of this.

If we except the 1.055-m. (3 ft. 5 5/8 in.) gauge, which is to be found only in Algeria and the origin of which it is difficult to explain, and the 0.60-m. (1 ft. 11 5/8 in.) gauge which appears to be adopted only in the Belgian Congo, there remain three types of line : the metre gauge, which is the most usual in French West Africa, the 1.067-m. (3 ft. 6 in.) gauge, which is the English type in use throughout South Africa and, finally, the 1.44-m. (4 ft. 8 3/4 in.) gauge adopted by the Algerian and Maroccan railways and which will probably be adopted for the Trans-Sahara route.

It may be questioned whether, in the French African colonies, it was a wise solution to create important routes with a gauge of 1.44 m. in the midst of an extensive railway system which has a metre gauge, thereby involving the creation of numerous transhipment centres.

The Algerian Paris, Lyons & Mediterranean Railway expresses the following opinion :

We consider that the normal 1.45-m. (4 ft. 9 in.) gauge is the only suitable gauge with heavy rails (approximately 46 kgr. per metre = 92.7 lb. per yard) so as to allow of the running of high powered engines and dispensing with double traction on steep gradients or for hauling heavy trains,

and the *Moroccan Railways* add :

The important point is to foresee the future, and it is very rarely that too adequate provisions have been made in this connection.

The Algerian State and the Tunisian Railways, however, hold a different view :

*Tunisian Railways.*

Our preference is for the metre gauge, which is more economic from the constructural point of view. We use this gauge for goods trains quite as heavy as those which run over the normal gauge, and at approximately equivalent speeds.

*Algerian State.*

The reproaches levelled at narrow gauge lines, i. e. lower speeds and lack of comfort, have lost much of their point as a result of the progress made in recent years in the running of trains and the improved construction of vehicles.

The Portuguese Railways express a similar opinion, and our experience of the two lines in Europe leads us to share it to a certain degree : with a gauge of 1 metre or of 1.067 m. (3 ft. 3 3/8 in. or 3 ft. 6 in.) it is possible to cope with practically as much traffic as with a 1.44-m. (4 ft. 8 3/4 in.) gauge. It is a question of the weight of the traction units, which is limited above all by the weight of the rail; to-day, in fact, many metre lines are laid with 30-kgr. (60.5 lb. per yard) rails, and even that cannot be regarded as a maximum.

Further, speeds of up to 70 km. (43.5 miles) an hour can easily be attained on these lines.

Nevertheless, if it is desired to attain on these main lines speeds comparable with those of the large European roads, *i. e.* in the neighbourhood of 100 km. (62 miles) an hour, it cannot be denied that the 1.44-m. line possesses a higher degree of stability.

But will it ever be practicable to run at such speeds in regions like the Sahara, where the supervision of the lines will present so many difficulties ?

We will add, as an interesting item of information, that the Railways of the Dutch East Indies have adopted the 1.067-m. (3 ft. 6 in.) gauge, and the French Railway Company of Indo-China and the Yunnan the metre gauge.

### 3. Construction and maintenance of lines.

Our next step was to ascertain what, from the economic point of view, were the more interesting solutions of a provisional character adopted in the early days of the construction of penetration railways.

We have not received any very characteristic information in this connection.

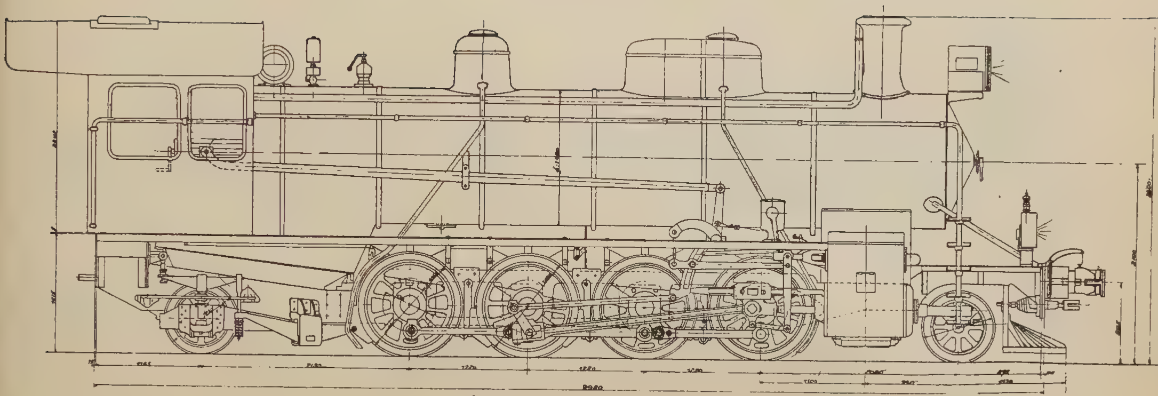
The Portuguese Railways merely state that in Mozambique a commencement was made with the laying of a 0.60-m. (1 ft. 11 5/8 in.) gauge line, but that this was subsequently converted into 1.067-m. (3 ft. 6 in.) gauge. On the same railway use was made of Jaca wood, which has special qualities as regards strength, for the construction of a bridge of 92-m. (302 feet) span.

On the Tunisian Railways small bridges of 0.80-m. (2 ft. 7 1/2 in.) span were built at the beginning in wood, being later replaced by concrete or steel structures.

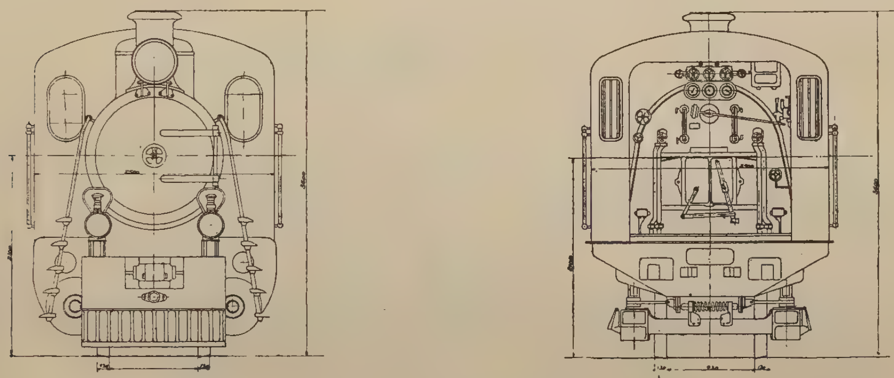
The secondary branch line from *Aïn-ghrasesia* to *Kairouan*, which crosses a fairly large river, is laid across the bed; this leads to several day's interruption of traffic each year and somewhat difficult maintenance work extending over six months in the year.

As a general rule all these railways are constructed with the normal characteristics found in lines of the same gauge in the mother countries. Gradients do not normally exceed 25 mm. (1 in 40), the

Side elevation.



End elevations.



Elevation of tender (bogies).

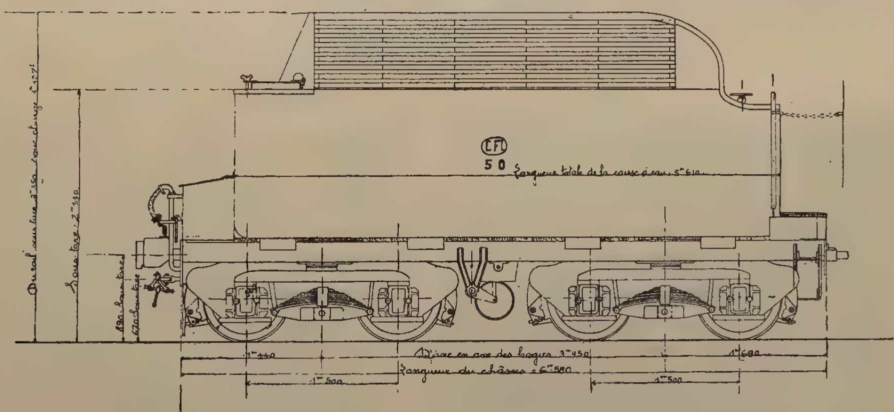



Fig. 1. — Upper Congo to the Great African Lakes Railway. — 54-ton locomotive.

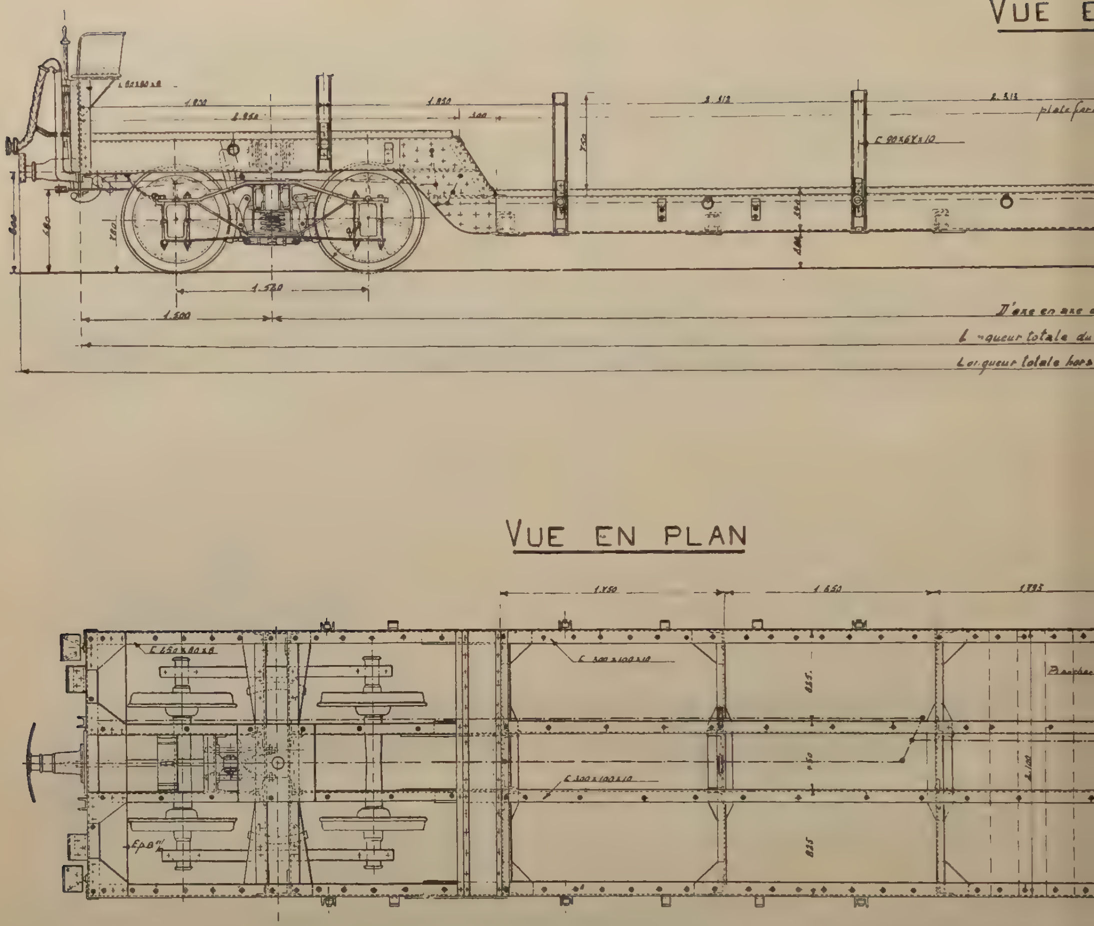



Fig. 2. — Upper Congo to the Great African Lakes Railw

*Explanation of French terms* : Vue en élévation = Side

only exception being the Algerian Paris, Lyons & Mediterranean Railways, in which case there are gradients of up to 30 mm. (1 in 33).

The radius of curves is never less than 100 m. (5 chains) for the metre gauge, except in Dahomey, where the minimum is 75 m. (3 3/4 chains). For the standard gauge the minimum radius is 150 m. (7 1/2 chains).

The minimum rail weights are 15 kgr. (30.2 lb. per yard) for 0.60-m. (1 ft. 11 5/8 in.) gauge, 24.4 kgr. (49.2 lb. per yard) for 1.067-m. (3 ft. 6 in.) gauge (Belgian Congo) and 30 kgr. (60.5 lb. per yard) for standard gauge.

The Algerian State Railways use 36-kgr. (72.6 lb. per yard) rails for their metre gauge; the Algerian Paris, Lyons & Mediterranean Railways use the 46-kgr. (92.7 lb. per yard) rail for standard gauge lines.

As regards sleepers, a large number of

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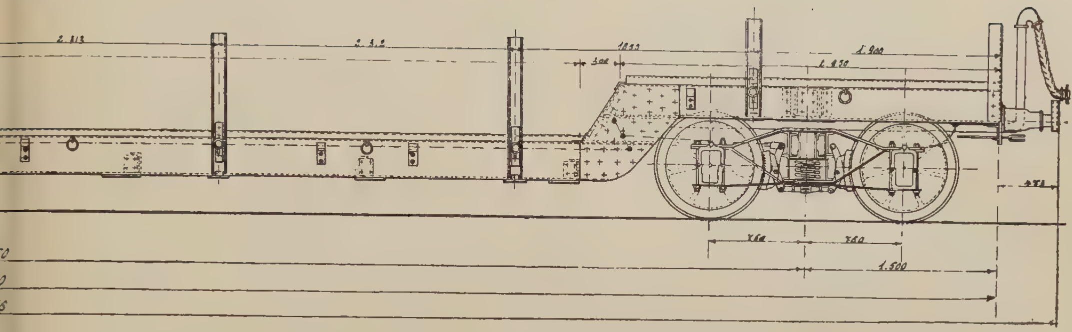
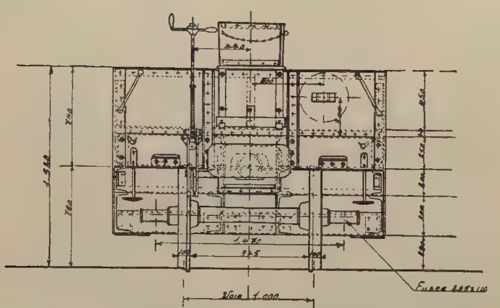


VUE PAR BOUT



gauge line. — Low-sided bogie wagon. — Load 20 tons.

en plan = Plan view. — Vue par bout = End elevation.

railways use the metal sleepers in preference to the timber sleeper. It may appear stange, the Dahomey Railways comment, to use metal sleepers in countries where timber is abundant, but it would be difficult to keep timber sleepers in a good state of maintenance in view of the inefficiency of native labour, and there would be the additional danger of the destructive ravages of white ants, the plague of tropical countries. On the other hand, with metal sleepers a track can be kept in a reasonable state of repair notwithstanding the mediocre maintenance work performed by the natives.

On the railways of the Belgian Congo the line was in the first instance laid on timber sleepers because of the difficulty of transporting material as far as Stanleyville; track laid on metal sleepers weighed, in fact, 100 tons to the kilometre (158 Engl. tons per mile), whereas with

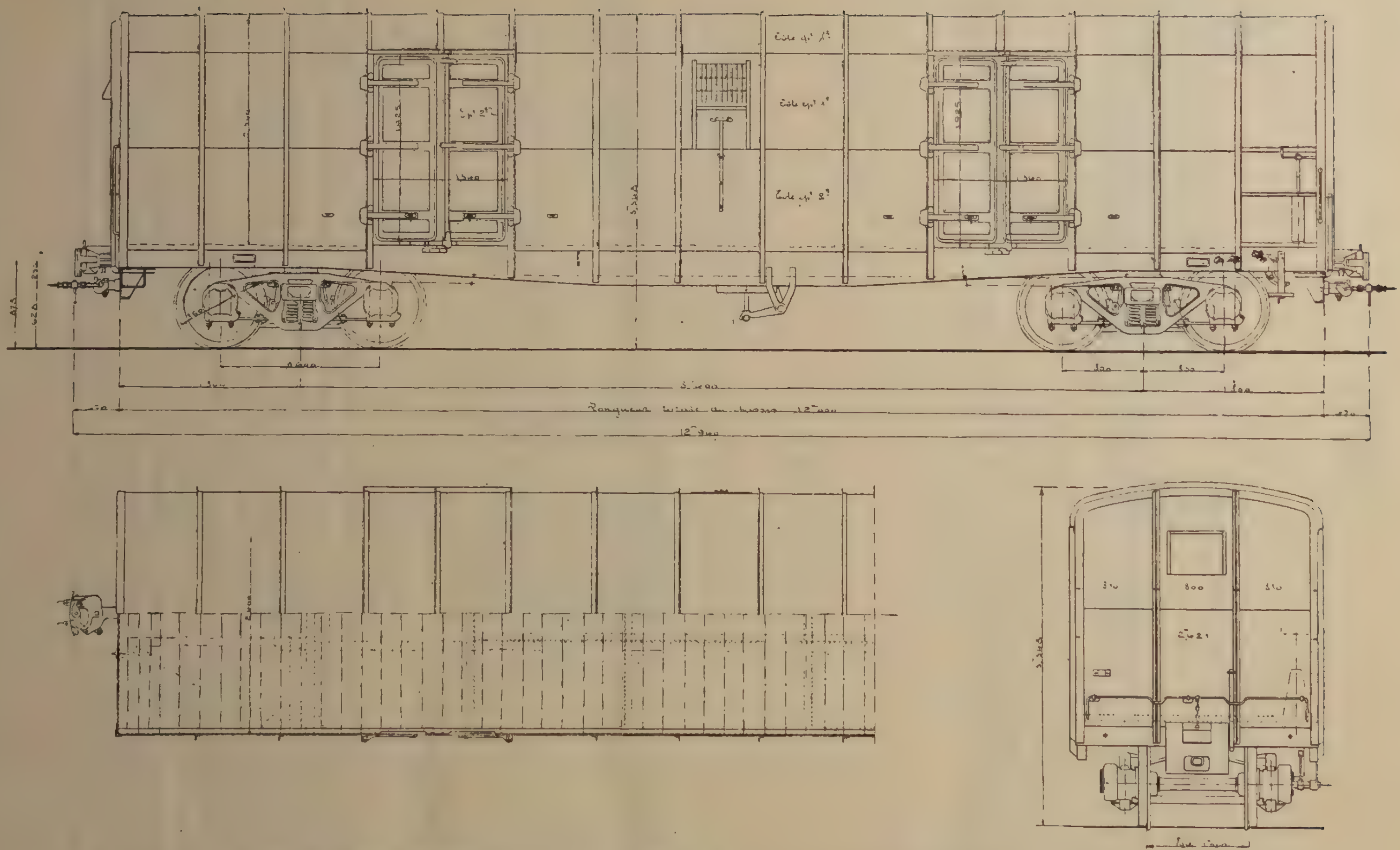


Fig. 3. — Upper Congo to the Great African Lakes Railway. — Covered bogie wagon with screw brake and vacuum brake. Load 27 tons.

timber sleepers the weight was only 50 t. (79 Engl. tons per mile). As soon, however, as the means of river transport had been improved, use was made of the 35-kgr. (77.2 lb.) metal sleeper.

### 4. Traction and rolling stock.

Generally speaking, these lines are served by steam locomotives of the types in uses on the lines in the mother countries; the only difference is that certain fireboxes are arranged for burning wood fuel.

In spite of the difficulties very often encountered in arranging for an adequate water supply, it has, up to the present, been quite the exception for a railway administration to resort to electric traction. According to the information received, the only case of electrification in Africa at the present day are on certain secondary lines in Algeria and on a portion of the lines of the Moroccan railways. The Moroccan Company uses the 3 000-volt continuous current, 1 400-H. P. electric locomotives with Westinghouse brake and recuperation brake, and 750-H. P. motor coaches. Electric traction has also been introduced in Madagascar, but we are without detailed information as to its working.

On other railways which had been contemplating electrification, the administrations have been held back by the problem of supervision of the electrified lines, as in countries with so low a level of civilisation there is alway danger of the circuits being cut by the natives.

In spite of these difficulties, both the French and the Belgian Congo Railway administrations are at present considering the utilisation of the large waterfalls of those regions for the electrification of their lines.

In view of the difficulty in arranging for an adequate water supply, the Tunisian Railways have been experimenting with Diesel electric locotractors, of from 120 to 250 H. P., which appear to be giving satisfaction. This method of traction may prove to have great avantages in a country like Tunis, where water is scarce and of poor quality; and it would also appear to be adaptable for use on metre gauge lines, all that is necessary being to provide the tractors with a sufficient number of motor bogies, and the problem of articulation — so difficult to solve in the case of the *Mallet* engines — does not even arise, since it is only a question of electrical connections between the frame and the bogies.

#### 1. *120-H.P. locotractor : 2-2-DE-1.*

This locotractor is driven by a Diesel motor of 120 H. P., four-stroke cycle, 500 revolutions to the minute. The motor has six cylinders arranged in V form, of 200 mm. (7 7/8 inches) bore and 240 mm. (9 7/16 inches) stroke. The motor drives directly a continuous current generator of 80 kilovoltamperes, the maximum voltage of which is 520 volts. The electric energy produced is transmitted to four traction motors which drive the four axles by means of gearing. The four motors may be connected either in series or in parallel by the driver by means of a coupling device. The locotractor is carried by two bogies each of two axles.

#### 2. *250-H.P. locotractor : 2-2-DE-2.*

The working of this locotractor is on the same principle as that of the 120-H. P. locotractor.

The motor is a 250-H. P., four-stroke cycle *Sulzer* motor, running at 350 revolutions per minute. The motor has eight cylinders arranged in V form, of 215 mm. (8 15/32 inches) bore and 300 mm.

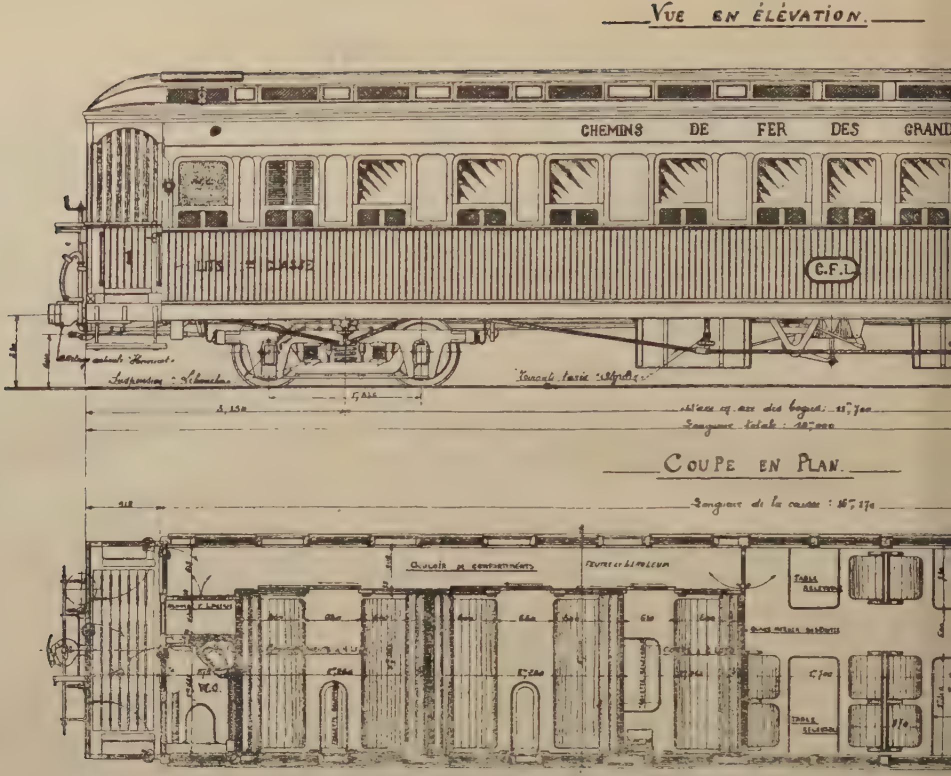



Fig. 4. — Sleeping car.

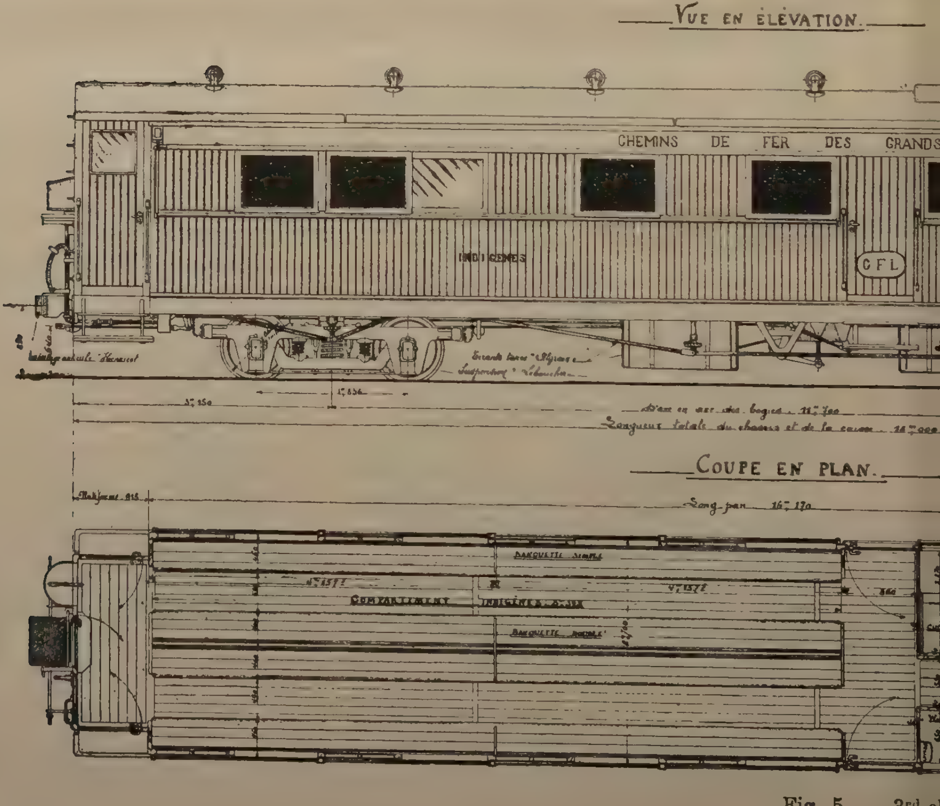
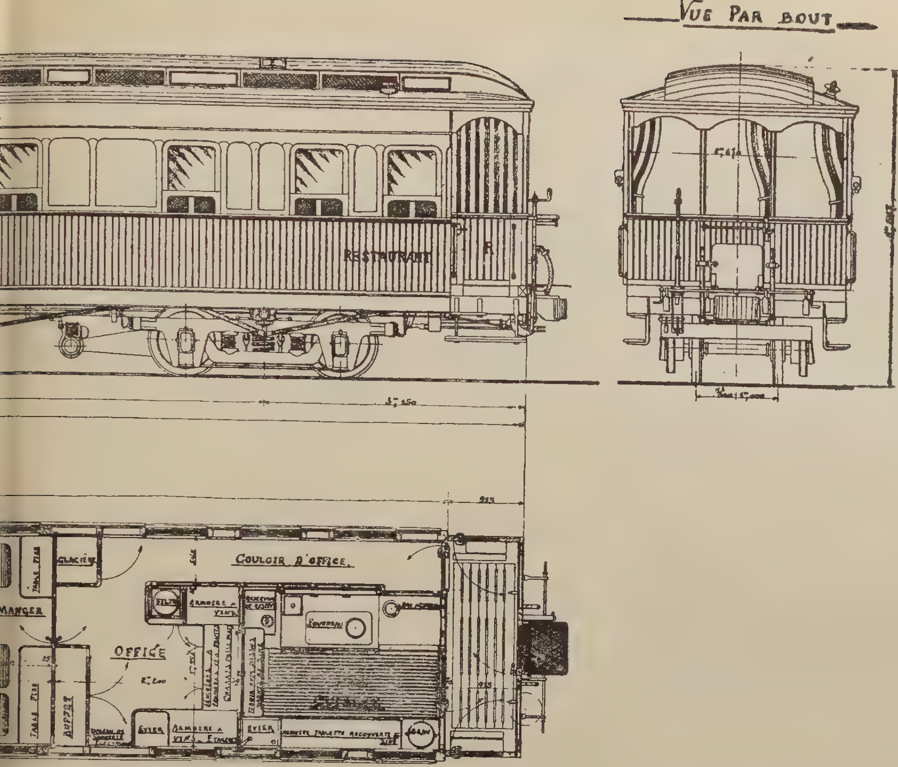
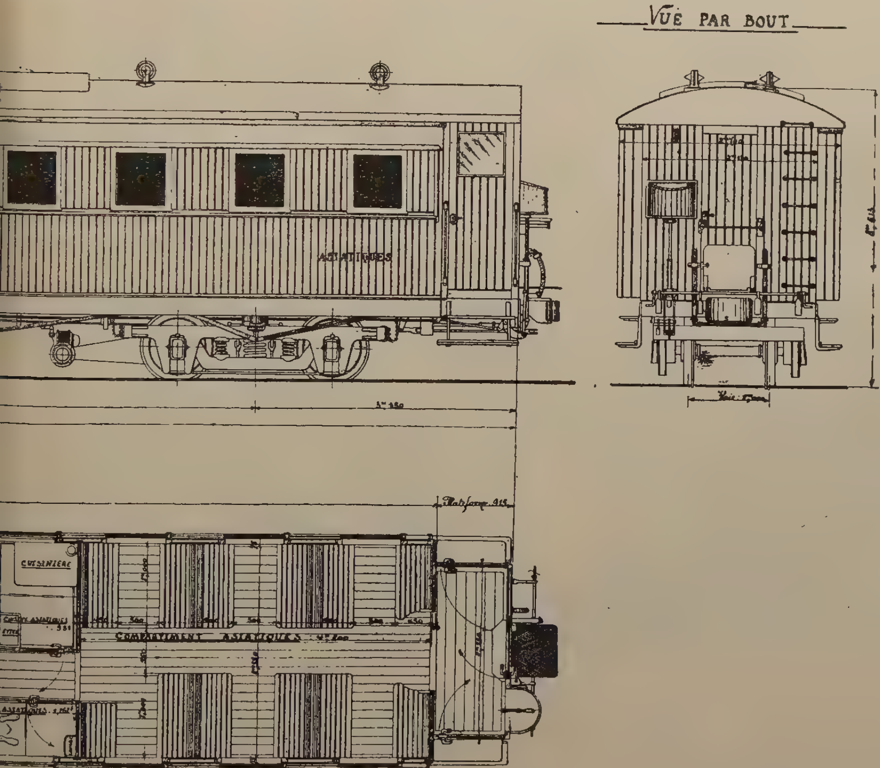



Fig. 5. — 3rd c




restaurant carriage.




for natives.

(11 13/16 inches) stroke. The continuous current generator can develop a power of 145 kilovoltamperes. The locotractor is carried by two four-wheeled bogies. All the axles are motor axles.

The same railways also use three main types of locomotives of respectively 40, 50 and 68 metric (39.4, 49.2 and 66.9 English) tons weight. The 68-ton type, which develops a tractive effort of 8 742 kgr. (19 272 lb.), has two 6-coupled radial trucks (tank engine). It would seem, however, that the most powerful metre gauge engine is the *Mikado*, of the Belgian Congo Railways, with separate tender, and which, with a weight of 52 metric (51.2 English) tons, develops a tractive effort of 12 696 kgr. (27 990 lb.). It has a grate area of 3 m$^2$ (32.3 sq. feet) and a total heating surface of 160 m$^2$ (1 722 sq. feet).

It is unfortunately impossible for us, within the limits of this report, to give a complete description of all the interesting types of engines which have been brought to our notice by the various companies; we can reproduce diagrams of only a few of them.

As regards carriages, certain railways, and in particular the North African railways, have adopted a most comfortable type in view of the large number of tourists which they have to transport each winter. Most of the railways use bogie carriages, similar in type to those in use on the railways of the mother countries. Certain railways have special carriages for the transport of natives.

The types of goods wagons are very varied, but here again there is great similarity with the types to be found on the railways of the mother countries.

The Belgian Railways of the Upper Congo to the Great African Lakes have sent us diagrams of some most interesting wagons of great carrying capacity, which show how a line with a 1-m. or 1.067-m. (3 ft. 3 3/8 in or 3 ft. 6 in.) gauge can be adapted to deal with heavy trains.

This company has also sent us diagrams of carriages which appear to us to be the most comfortable at present constructed for narrow gauge lines.

We append the diagrams of this rolling stock to the present report.

### 5. Working.

According to the information with which we have been furnished, the working regulations are identical with those of railways in the mother countries. The types of station call for no particular comment. The Algerian State Railways inform us, however, that the engine sheds, water cranes, goods sheds and employees' dwellings are erected within a fortified enclosure.

Running speeds vary between 20 km. (12.4 miles) an hour on the Niger, 70 km. (43.5 miles) an hour on the Tunisian Railways (metre gauge) and on the Congo Railway, and 72 km. (44.7 miles) an hour on the Moroccan Railways (standard gauge).

It would appear from these details that on lines where speed is sought, no better results are obtained with the standard than with narrow gauge, and this confirms the opinion which we have expressed above, namely that it is doubtful whether it would be prudent to attempte to run at higher speeds in regions whe:. supervision of the line is so difficult.

### 6. Size of Railway Systems. Working results.

According to the information received, the Belgian Congo Railways have a total length of 2 773 km. (1 723 miles), while

about 1 000 km. (621 miles) are in course of construction.

The Dutch East Indies Railways have 529 km. (329 miles) in operation, 120 km. (75 miles) under construction and 600 km. (373 miles) are projected.

In the Portuguese colonies, 1 071 km. (665 miles) are in operation in Mozambique, while 2 210 km. (1 373 miles) are in operation and 1 000 km. (621 miles) are projected in Angola.

We should like to have been in possession of exact statistics in regard to the French colonial railways, but these had not reached us at the moment of writing this report; from information received they would appear to comprise about 10 000 km. (6 214 miles) of line (Colonies and Protectorates).

The Belgian Railways from the Upper Congo to the Great African Lakes are prosperous : traffic units increased from 24 millions in 1921 to 98 millions in 1927. and receipts for the latter year amounted to 43 576 595 fr., against expenses of 29 619 083 fr., leaving a profit of 13 957 512 fr. on a total capital investment of 168 270 714 fr.

The Railways of the Dutch East Indies are also working at a profit : their receipts amount to 4 576 000 florins and their expenses to 3 146 000 florins, with a capital investment of 64 634 000 florins.

As regards the French Colonial Railways, those in Africa are far from producing results comparable to those obtained on the Belgian Congo Railways; the Algerian Railways are working at a loss. The Moroccan Company alone shows a profit, which amounts to 19 490 000 fr., but the capital invested is 621 228 000 fr. Finally, the Railways of Indo-China and the Yunnan, which made a net profit of 12 1/2 million francs in 1921, show for 1928 receipts of 68 606 965 fr. as against expenses of 43 890 986 fr., giving a profit of 24 715 979 fr. on a capital of 17 500 000 fr. in shares (in 1907) and 87 millions of debentures.

We should like to have been able to prepare comparative tables of costs for the various railways under consideration, distinguishing between the three elements : working, traction and permanent way; but the information which we have received is not sufficient to enable us to do this satisfactorily.

We have also endeavoured to gain some idea of the amount of labour employed by the various railways, of the extent to which use is made of coloured labour and of the cost of the latter as compared with the cost of European labour.

It is obvious that the amount of labour varies according to the traffic, and the proportion of European employees depends firstly on the distance from the mother country, secondly on the facilities for engaging such labour, and lastly, and especially, on the climate.

On certain equatorial railways, in Dahomey, on the Ivory Coast and on the Niger, the proportion of white to coloured labour is quite insignificant, for Europeans would be quite unable to perform any active railway work during the daytime.

On certain railways, as for example those of the Dutch East Indies, native labour is paid at the same rate as European labour.

The same remark applies to the Algerian railways.

In order to complete these details we think it well to give the replies received from the Algerian Paris, Lyons & Mediterranean Railway on this subject :

*Operating Department.*

Number of employees per kilometre (per mile) of line :

0.58 (0.93) on the Blida-Djeffa line;

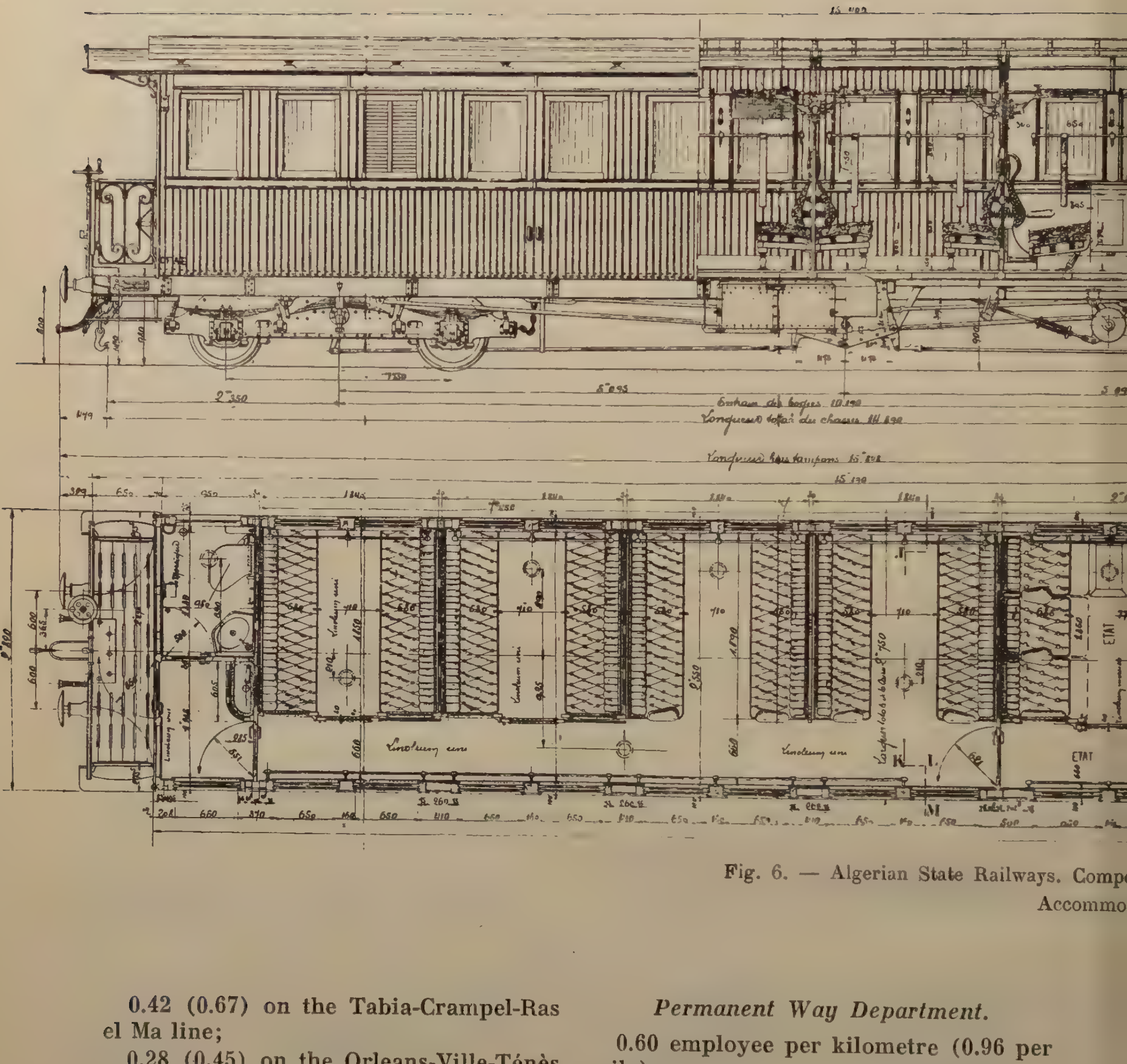


Fig. 6. — Algerian State Railways. Comp
Accommo

0.42 (0.67) on the Tabia-Crampel-Ras el Ma line;

0.28 (0.45) on the Orleans-Ville-Ténès line;

0.31 (0.50) on the Tlemcen-Beni Saf line.

Native labour is employed in the proportion of 4 % in the case of men on the staff and 90 % in the case of dayworkers.

*Permanent Way Department.*

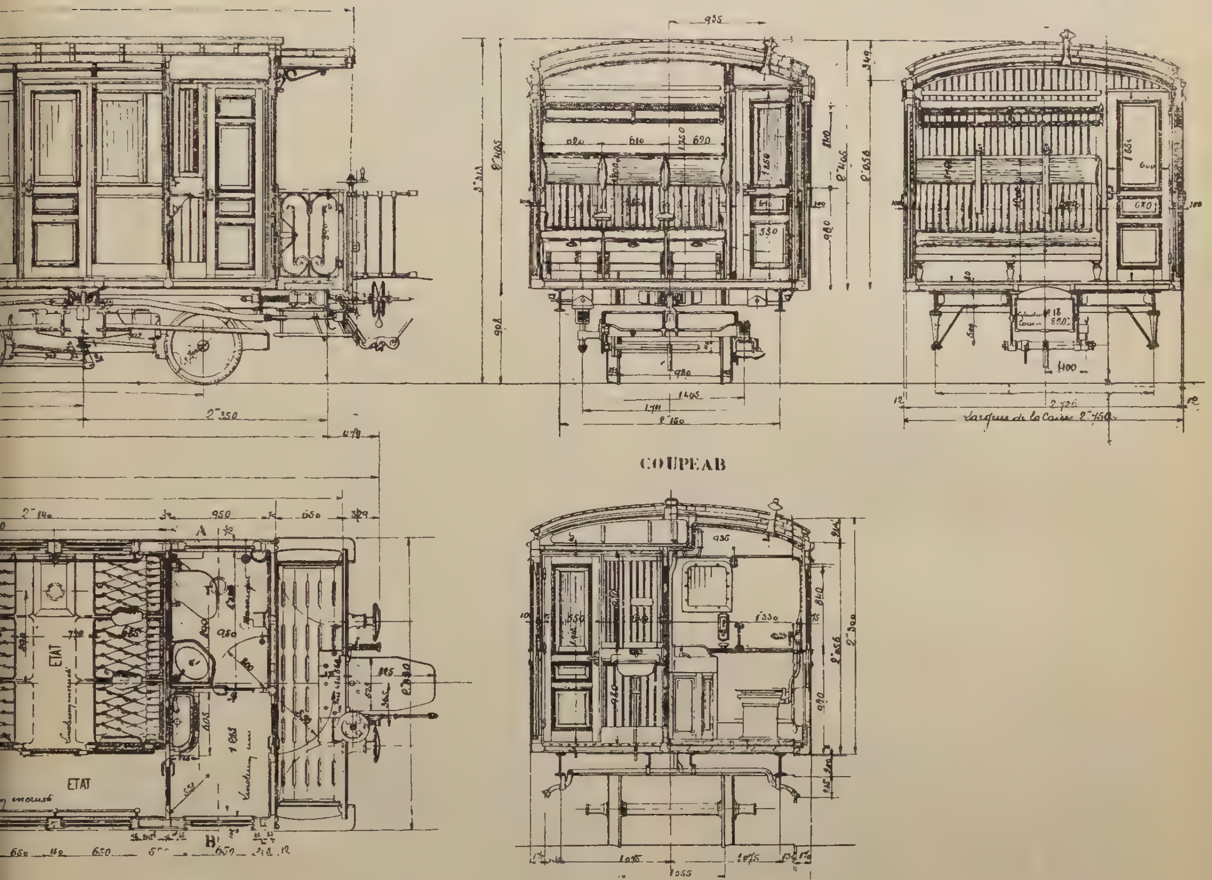
0.60 employee per kilometre (0.96 per mile).

Native labour is employed in the proportion of 35 % in the case of platelayers, and almost entirely in the case of labourers.

*Rolling Stock and Traction Department.*

Our statistics do not enable us to give

Cross section CDEFGH    Cross section IJKLM




iage, 1st and 2nd class, for metre gauge lines.

s : 12 seats.

24 —

L : 36 —

the required data for this service, this staff taking part in the work of our lines as a whole.

*Cost of labour :*

The cost of labour is practically the same as on the railways of the mother country in the case of skilled permanent staff.

As regards day-labourers there is an appreciable difference, the natives receiving approximately 75 % of the remuneration above-mentioned.

Among the railways which utilise native labour on a large scale, the Belgian Congo Railway Company has also supplied information which we think it will be equally interesting to reproduce :

The number of white employees per

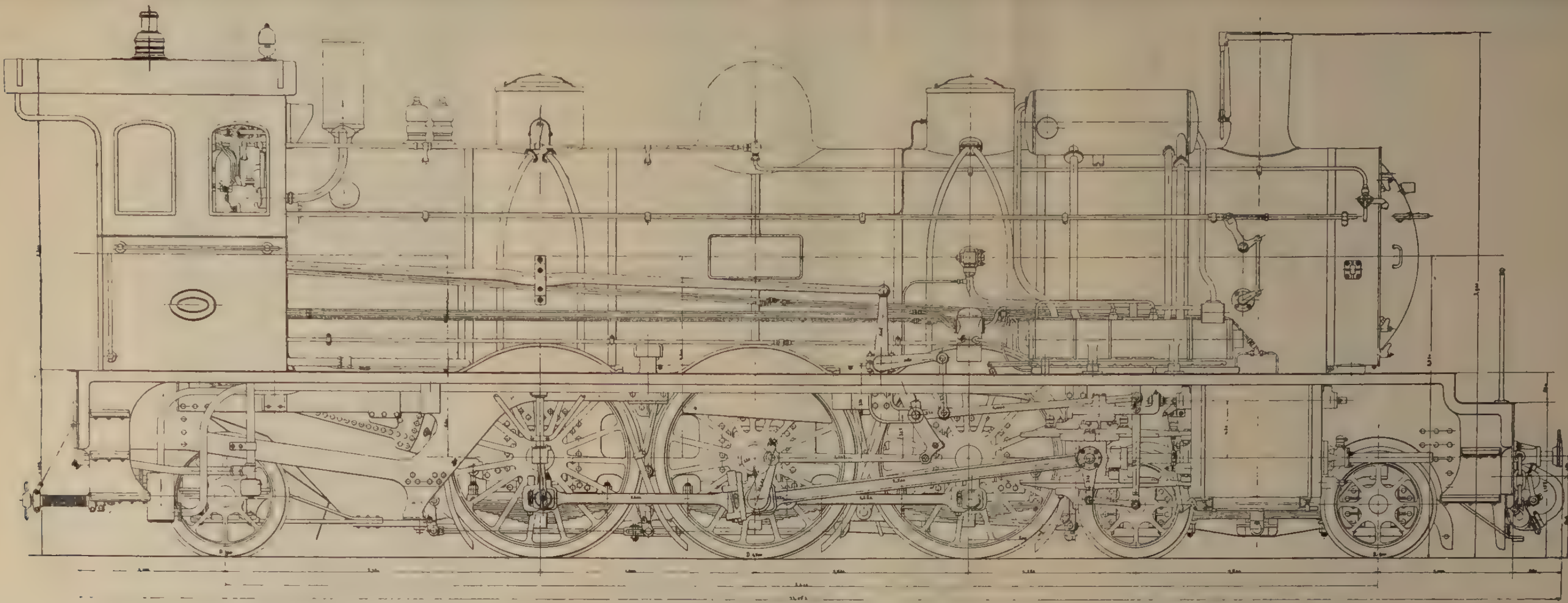


Fig. 7. — Tunisian Railway Company. — Narrow gauge lines. — Two-cylinder locomotive, *Pacific* type, superheated, 6-coupled with leading bogie and trailing pony truck.

*Principal dimensions.*

| | | |
|---|---|---|
| Weight of engine empty | 52 000 kgr. | (114 650 lb.) |
| Water in boiler and fuel on grate | 6 000 — | (13 230 lb.) |
| Weight of engine in working order | 58 000 — | (127 880 lb.) |
| Load on coupled wheels | 36 000 — | (79 370 lb.) |
| Load on bogie | 13 000 — | (28 660 lb.) |
| Load on trailing axle | 8 900 — | (19 620 lb.) |
| Average diameter of boiler | 1.480 m. | (4 ft. 10 1/4 in.) |
| Boiler pressure | 12 kgr. per cm² | (170.7 lb. per sq. inch). |
| Number of 125 133 (4 29/32-5 1/4 inches) tubes | 21 | |
| Number of 45/50 (1 49/64-1 31/32 inches) tubes | 120 | |
| Length of tubes | 5.000 m. | (16 ft. 5 in.) |
| Heating surface of tubes | 126.05 m² | (1 356.84 sq. feet). |
| Heating surface of firebox | 8.93 m². | (96.12 sq. feet). |
| — — boiler | 134.98 — | (1 452.96 sq. feet). |
| Superheater surface | 45.50 — | (489.77 sq. feet). |
| Total heating surface | 180.48 — | (1 942.74 sq. feet). |
| Grate area | 2.20 — | (23.68 sq. feet). |
| Diameter of cylinders | 0.460 m. | (18 1/8 in.) |
| Piston stroke | 0.610 — | (24 in.) |
| Diameter of coupled wheels | 1.500 — | (4 ft. 11 in.) |
| — bogie wheels | 0.800 — | (2 ft. 7 1/2 in.) |
| — trailing wheels | 0.900 — | (2 ft. 11 1/2 in.) |
| Total wheel base | 8.600 — | (28 ft. 2 5/8 in.) |
| Total length of engine | 11.060 — | (36 ft. 3 7/16 in.) |
| Width of engine | 2.610 — | (8 ft. 6 3/4 in.) |
| Distance between rails | 1.000 — | (3 ft. 3 3/8 in.) |

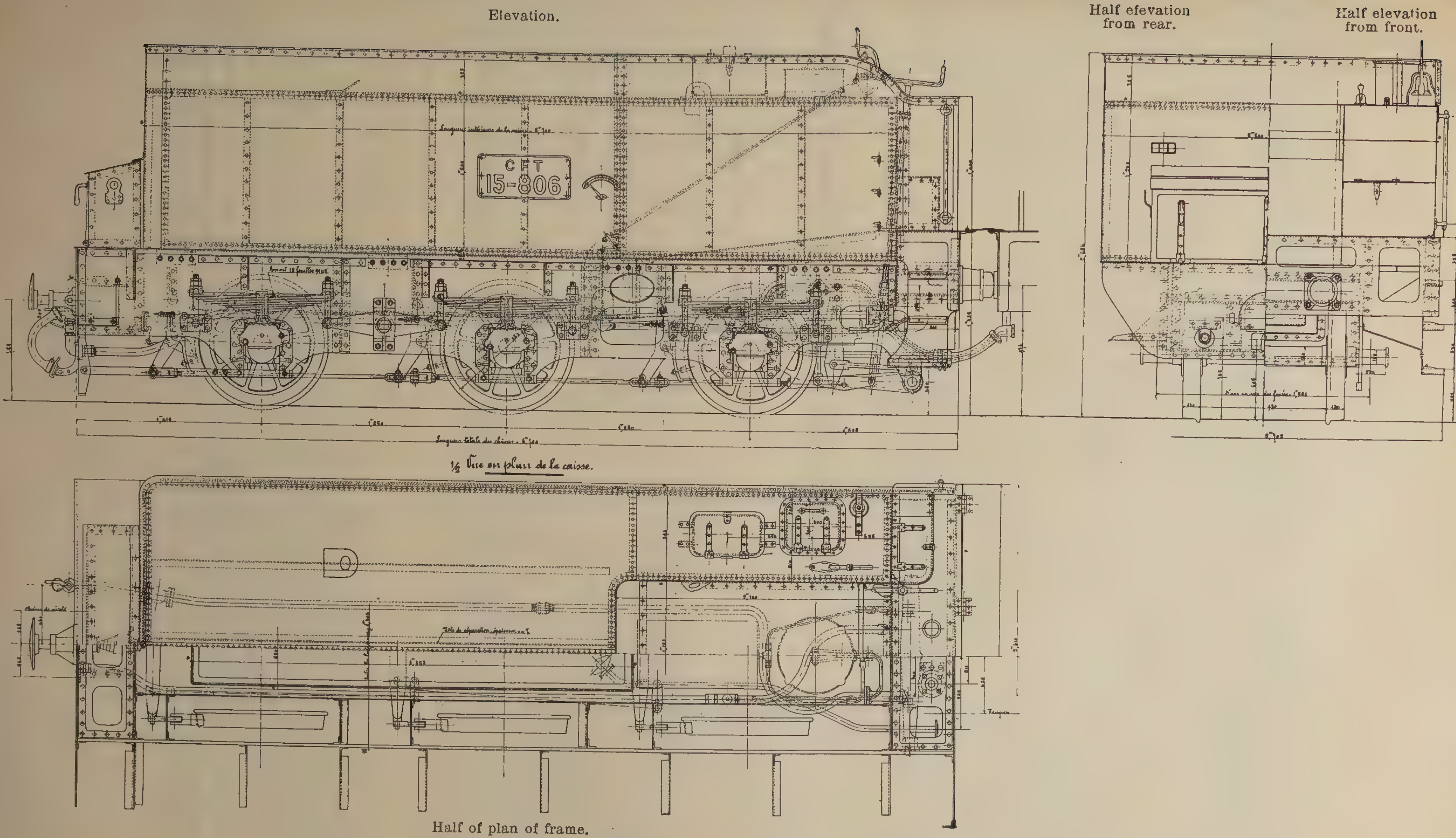



Fig. 7 (*continued*). — Tunisian Railway Company. — 6-wheeled tender of 15-m³, (3 000 gallons) capacity (series 751).

Longitudinal section through 1st class compartment.

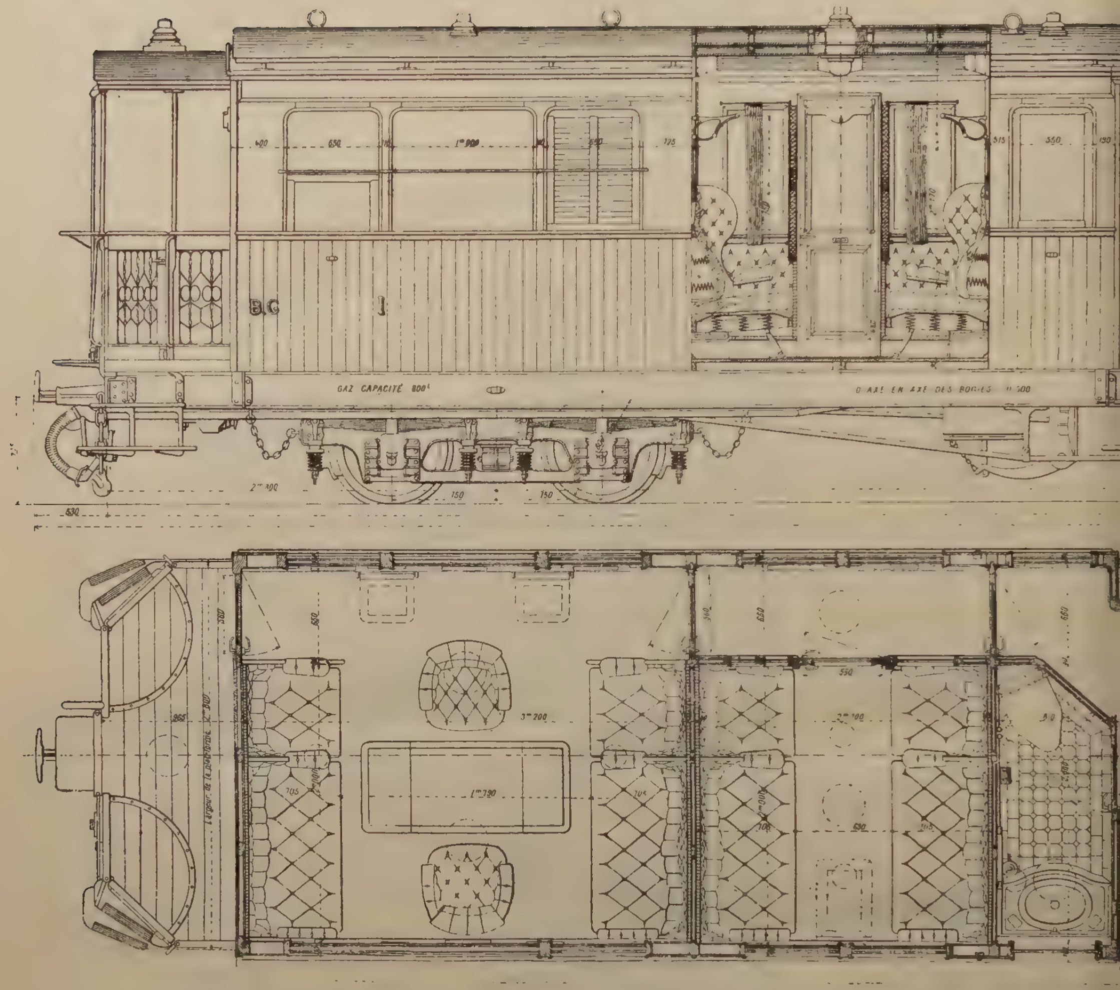



Fig. 8. — Bône-Guelma line and extensions.

*Explanation of French terms* : Co

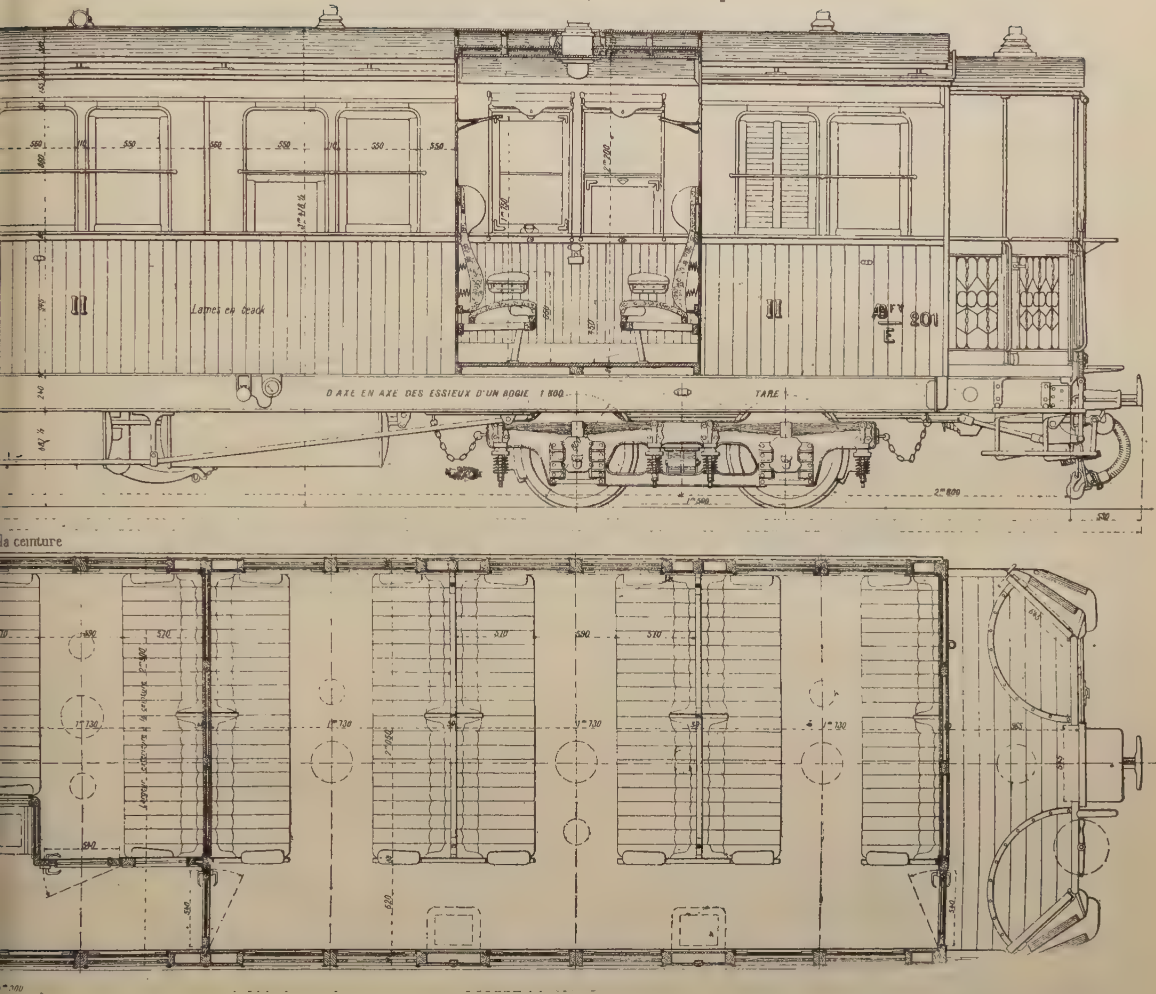
kilometre of line is 3.64 (5.86 per mile). We also employ coloured labour, in the proportion of 30 natives to one European.

The company provides the European employees with free first-class travelling, medical attention, medicine and dwelling accomodation.

After three years' service employees are entitled to six months' leave on special remuneration.

The remuneration is very variable, ranging from 50 000 to 150 000 fr., plus family allowances, travelling expenses, etc.

:xterior elevation. Longitudinal section through 2nd class compartment.




(Reproduced from *Revue Générale des Chemins de fer.*)

lines. — Composite carriage, 1st and 2nd class.

. Horizontal cross section at waist rail.

The native labour is excellent and efficiently replaces European labour for sertain classes of work, such as the laying and maintenance of the permanent way, the felling and preparing of timber, ballasting and earthwork.

This labour is very reliable and capable of a high output.

For the preparation of specialised labour for the workshops, offices and station services, training schools have been provided by the Company. They provide instruction for the most promising of the natives and turn them out as fully skilled employees.

Engines are all driven by native dri-

Table of general statistics in respect of the Penetratic

| COMPANIES. | Length in operation. | Length under construction or projected. | Gauge. | Capital. | Receipts. |
|---|---|---|---|---|---|
| | Km. (miles) | Km. (miles) | Metres. (feet and inches) | | |
| Belgian Congo . . . . . . | 2 773 (1723) | 1 150 (715) | 1.067 (3 ft. 6 in.) 0.60 (1 ft. 11 5/8 in.) | 168 620 714 (1) | 43 576 595 |
| Algerian State . . . . . . | 810 (503) | 15 (9) | 1.00 (3 ft. 3 3/8 in.) 1.055 (3 ft. 5 5/8 in.) | ... | 10 160 000 |
| Tunisian . . . . . . . . . | 1 583 (984) | 26 (16) | 1.00 (3 ft. 3 3/8 in.) 1.45 (4 ft 9 5/64 in.) | 147 207 553 (3) | 125 146 716 ( |
| Paris-Lyons-Mediterranean (Algerian lines). | 480 (298) | 256 (159) | 1.45 (4 ft. 9 5/64 in.) | ... | 12 887 435 |
| Eastern Dahomey . . . . | 80 (50) | 545 (339) | 1.00 (3 ft. 3 3/8 in.) | 19 000 000 | 1 145 256 |
| Cal Dahomey. . . . . . . | 293 (182) | | | 4 015 905 | 6 984 070 |
| Ivory Coast . . . . . . . . | 488 (303) | 70 (43) | 1.00 (3 ft. 3 3/8 in.) | 100 000 000 | 16 500 000 |
| Conakry-Niger . . . . . . | 662 (411) | ... | 1.00 (3 ft. 3 3/8 in.) | 67 600 000 | 9 830 449 |
| Thiès-Niger. . . . . . . . | 1 246 (774) | 140 (87) | 1.00 (3 ft. 3 3/8 in.) | 166 000 000 | 57 483 899 |
| Dutch East Indies. . . . . | 529 (329) | 720 (447) | 1.067 (3 ft. 6 in.) | 64 634 000 (4) | 4 576 000 |
| Portuguese Africa . . . . | 3 281 (2039) | 1 000 (621) | 1 067 (3 ft. 6 in.) | ... | ... |
| Moroccan Company . . . | 570 (354) | 745 (463) | 1.45 (4 ft. 9 5/64) | 621 228 214 (5) | 68 591 054 |
| Tangiers-Fez . . . . . . . | 315 (196) | ... | 1.45 (4 ft. 9 5/64) | 570 000 000 | 22 400 000 |
| Indo-China & Yunnan . . | 854 (531) | ... | 1 00 (3 ft. 3 3/8) | 104 006 000 | 63 606 965 |

(1) 18 910 000 debentures (Belgian fr.) — (2) Of which 24 931 116 fr. in respect of taxation. — (3) Including

ilways which have replied to the Questionnaire

| Expenses. | Working results. | Years in which lines opened. | Traction. | Maximum speed. | Commercial speed. | Maximum gradients. |
|---|---|---|---|---|---|---|
| | | | | Km (miles per hour) | Km. (miles per hour) | |
| 29 619 083 | + 13 957 512 | 1906 — 1925 | Steam. | 70 (43.5) | 28 (17.4) | 1 in 50. |
| 12 838 000 | — 2 678 000 | ... | — | 60 (37.3) | 35 (21.7) | 1 in 40. |
| 09 173 148 | + 15 973 568 | 1877 — 1927 | — | 70 (Stand. G.) (43.5)<br>65 (Nar. G.) (40.4) | 44 (27.3)<br>45 (28) | 1 in 50. |
| 20 139 982 | — 7 252 547 | 1891 — 1924 | — | 60 (37.3) | 30 (18.6) | 1 in 33. |
| 1 027 765<br>3 888 530 | + 117 491<br>+ 3 096 540 | 1900 — 1913 | — | 40 (24.8) | 22 (13.7) | 1 in 50. |
| 11 450 000 | + 5 050 000 | 1900 — 1906 | ... | ... | 32 (19.9) | 1 in 40. |
| 9 580 092 | + 250 357 | 1900 — 1914 | ... | 35/50 (21.7-31) | 16/38 (9.9-23.6) | 1 in 40. |
| 52 944 931 | + 4 538 968 | 1881 — 1923 | ... | 40/51 (24.8-31.7) | 20/30 (12.4-18.6) | 1 in 40. |
| 3 146 000 | + 1 430 000 | 1912 — 1926 | ... | 45 (28) | 18/32 (11.2-19.9) | 1 in 40. |
| ... | ... | ... | ... | ... | ... | 1 in 40. |
| 49 101 111 | + 19 489 943 | 1923 — 1928 | Steam and electricity. | 72 (44.7) | 55 (34.2) | 1 in 67. |
| 20 400 000 | + 2 000 000 | 1927 | ... | 55 34.2) | 37 (23) | 1 in 67. |
| 43 890 986 | + 19 715 979 | 1903 — 1910 | Steam. | ... | ... | ... |

1 720 755 debentures. — (4) Florins. — (5) 1/10th held by Company.

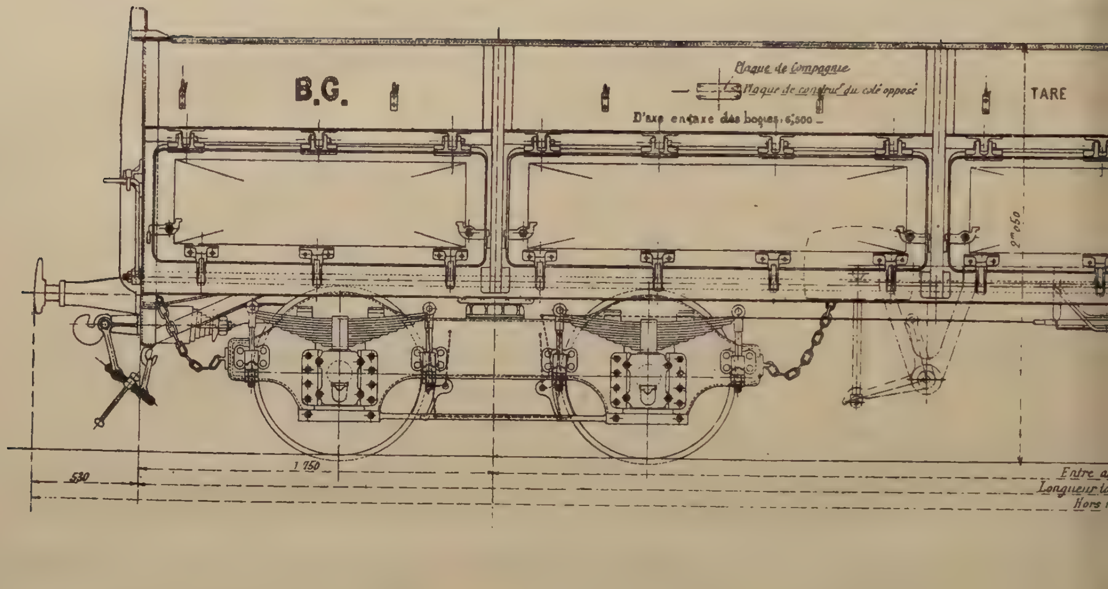
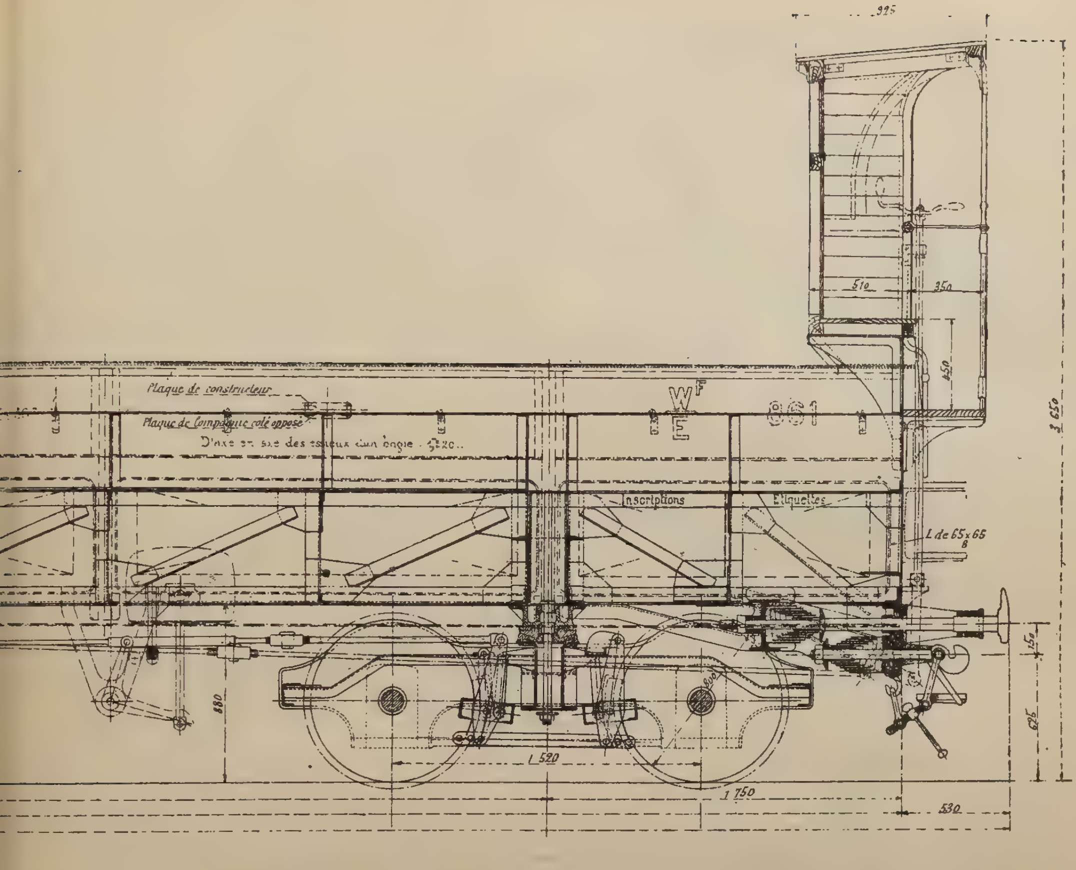



Fig. 9. — Tunisian Railway Company — Narrow gauge




(Reproduced from the *Revue Générale des Chemins de fe*).

n mineral wagon, self-discharging. — Elevation and plan.

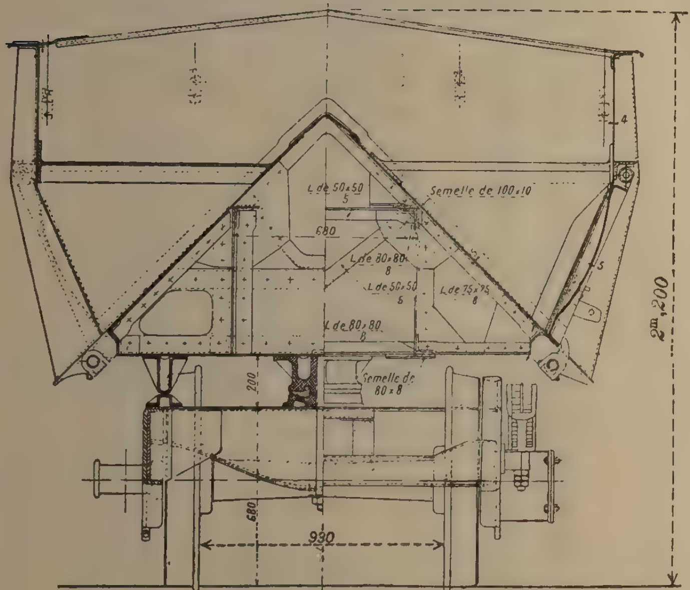



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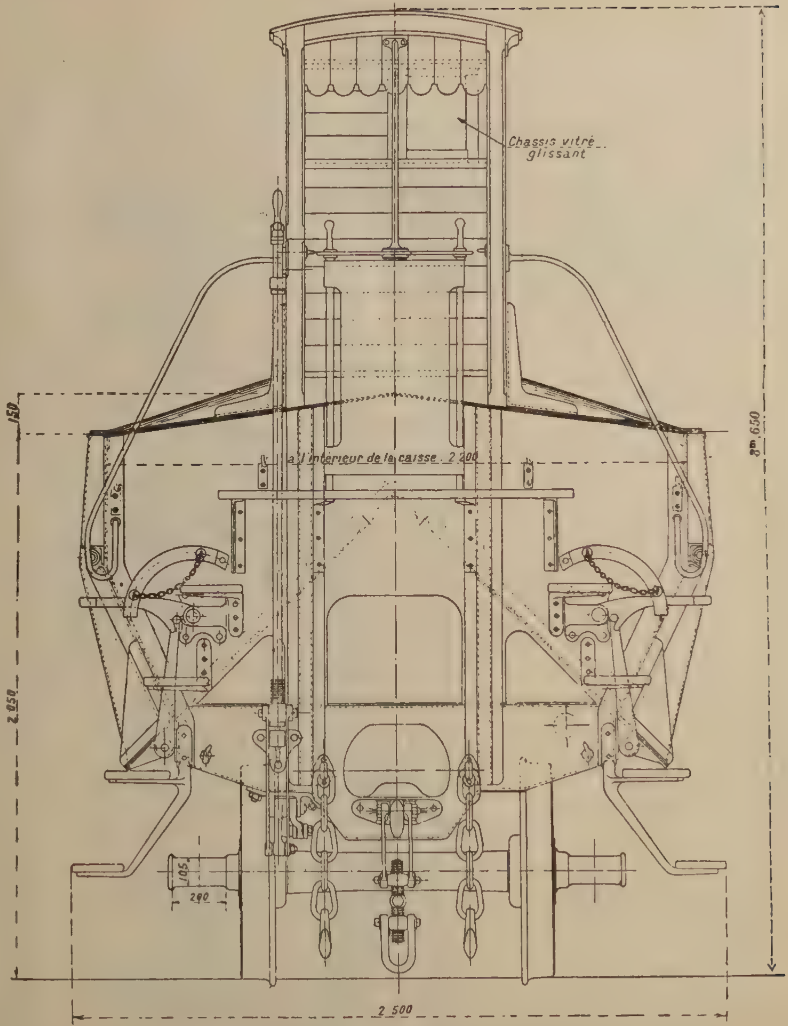
Fig. 9*a*. — Cross-section.




(Reproduced from the *Revue Générale des Chemins de fer.*)

Fig. 9*b*. — End elevation. — Mechanism of doors.

vers. In the workshops there is one white for seven or eight machine tools; he supervises the native employees, places the more difficult pieces of work on the machines and checks the operations.

Each efficient native workman is given one or two pupils to train.

The cost of native labour is relatively low as regards wages, but the regulations require the company to provide the natives with food, clothing and a brick dwelling. Taking all this into account, native labour costs from 7 to 10 fr. per day, according to the place and the cost of food.

We have selected the following items of information from the replies received from other companies :

*Tunisian Railways.* — This company employs 51.5 % of native labour for the permanent way, 12.5 % for traction and 44 % for the operating department. The cost of native labour is about half that of labour in the mother country.

*Dahomey :* from 1.5 to 2 natives and from 0.08 to 0.005 Europeans per kilometre of line (2.4 to 3.2 natives and 0.13 to 0.008 Europeans per mile).

*Ivory Coast :* 4.6 natives and 0.3 Europeans per kilometre (7.4 and 0.48 per mile respectively).

*Conakry-Niger :* exclusively coloured labour.

*Thiès to the Niger :* 444 Europeans employees and 7 883 natives. The duties of the Europeans are limited to training, supervision and control. Native labour, in spite of its inferior output, is utilised wherever possible.

*Dutch East Indies :* There is no difference in the remuneration of European and native labour (1 % and 99 %).

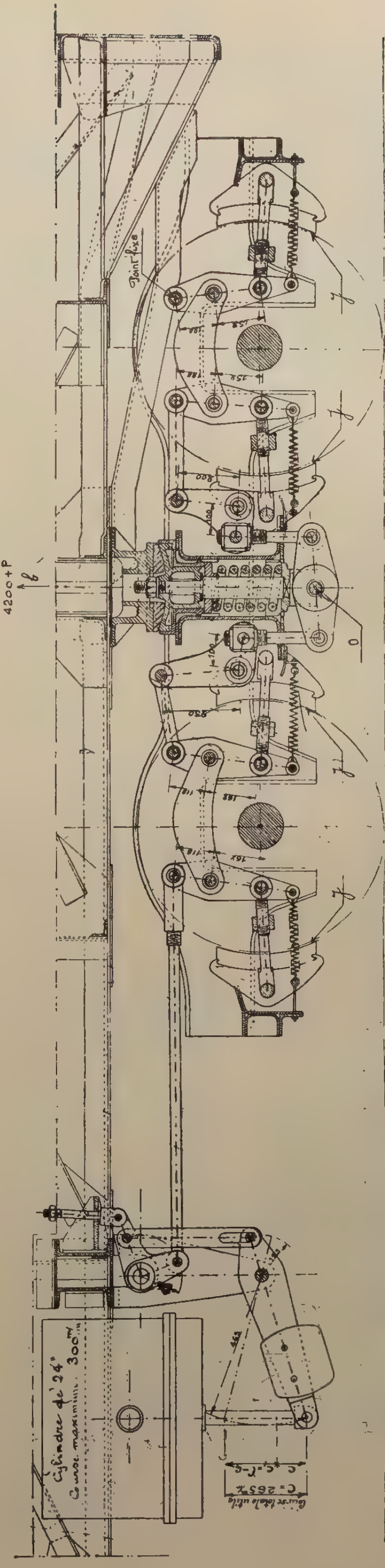



Fig. 10. — Tunisian Railway Company. — Chamon automatic variable power brake for mineral wagon. — General diagram of brake rigging.

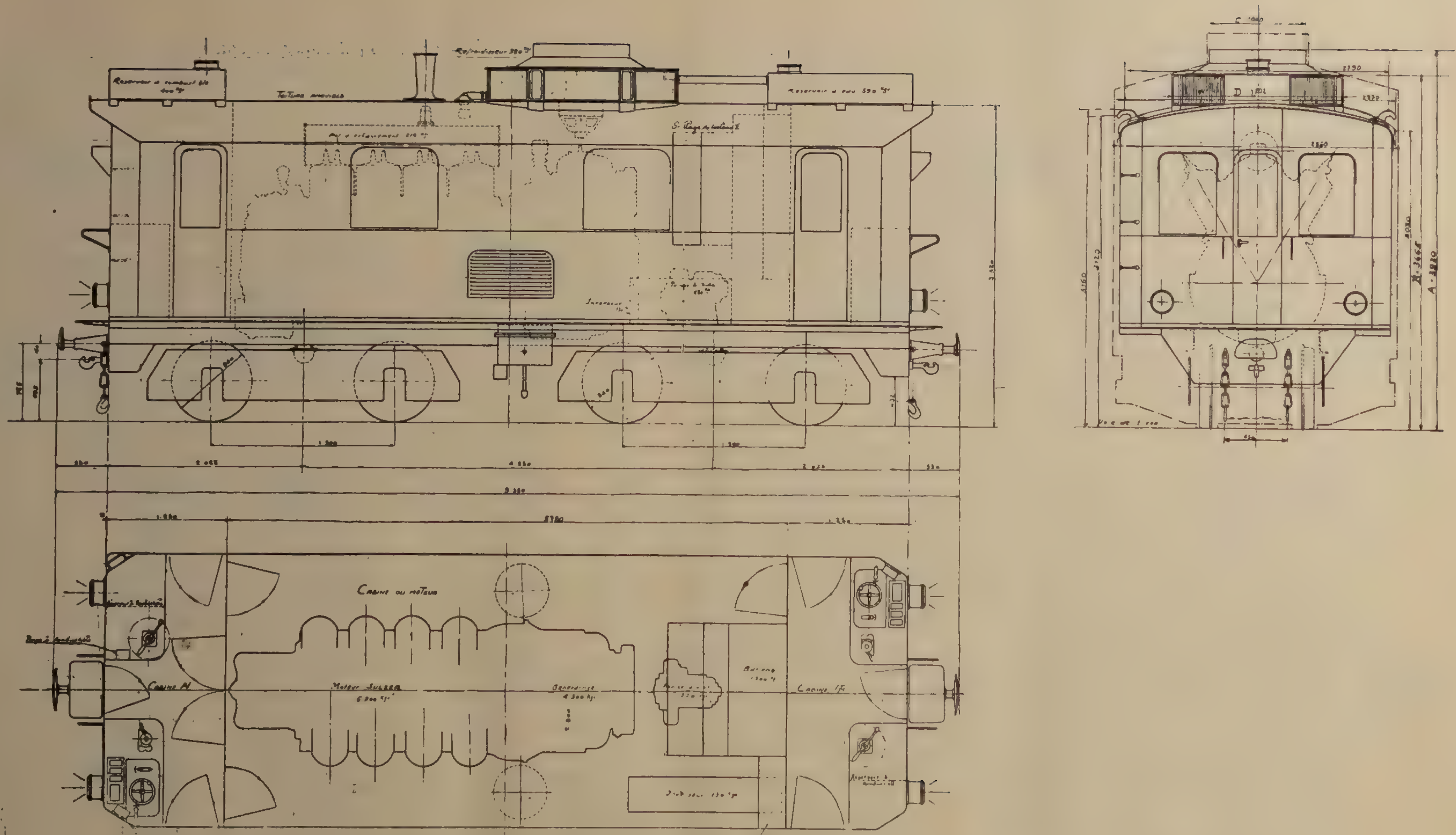


Fig. 11. — Tunisian Railway Company. — 250-H. P. Sulzer Diesel-electric engine. — General diagram.

As a general rule, if the working of these railways is unprofitable, any deficiency is borne either by the mother country or by the colony in question.

At the outset of our inquiry we asked for the views of companies on the use of motor traction as a means of penetration; we particularly wished to ascertain whether motor transport had had any influence on existing railways.

It would appear that for real penetration lines, i. e. for railways operating in countries which are still in a low state of civilisation, this competition is in most cases negligible. Only in the case of the Tunisian Railways, the Algerian lines of the Paris, Lyons & Mediterranean Railway and the Moroccan Railways is it stated that there has been any appreciable reduction in passenger receipts during recent years as a result of the competition of motor transport.

The existence of this competition is also reported by the Dutch East Indies Railways. These railways have organised motor bus connections and independent motor bus services. The Algerian lines of the Paris, Lyons & Mediterranean Railway have entered into agreements with the competing services.

The Moroccan Railways complain of competition even in the transport of goods, and they have already been compelled to lower their rates in order to meet this competition.

Finally, we asked the various companies whether they had any personal views to express with regard to the development and the future of penetration railways. We have, not, however, found any observations in this connection in their replies, except in the case of the Tunisian Railways, which seem to imply that the so-called penetration railways have now more or less reached their limit of development.

* * *

To summarise, it appears from the replies received to our questionnaire that, either as regards the construction of railway lines or as regards their equipment, penetration railways act on the experience gained by the Railways of the mother country, and generally adopt their types of permanent way and rolling stock. As, however, narrow gauge traffic is much more extensive than in the mother country, it has been necessary to adopt wagons and carriages of much greater capacity on the narrow gauge lines.

While fulfilling the policy followed by the respective governments, the future efficiency of these lines should be the first case of those who are responsible for their planning and construction.

In this connection the Belgian Congo Railway states :

The efficiency of a railway depends much more upon its loading gauge, gradients and curves than upon the gauge of its track.

It was in accordance with this principle that they adopted the 1.067 m. (3 ft. 6 in.) gauge, as being the best adapted for broken country. They consider that with 30 kgr. (60.5 lb. per yard) rails, this gauge can carry 16 tons per axle, which is amply sufficient. The British colonies of South Africa having, it appears, adopted the same view, the whole of the railways in South Africa will eventually have a uniform gauge of 1.067 m. (3 ft. 6 in.).

We in Europe have only one criticism to level against our metre gauge lines, namely the inconveniences caused by the necessity for transhipment at the points of contact with standard gauge lines : the

actual cost of the operation, damage to the goods transhipped, immobilisation of rolling stock at the tranship point and loss of time in conveyance of goods.

Given reasonable gradients and a sufficiently heavy rail, these lines can carry almost as heavy loads as the 1.44 m. (4 ft. 8 3/4 in.) line.

With rolling stock of the type constructed at the present day, however, a speed of 80 km. (50 miles) an hour must be considered as a maximum for the metre track, whereas the admitted speed on standard gauge lines is 120 km. (75 miles) an hour.

Certain railway administrations appear to think that it may be desired in future to cover at high speeds the long stretches of line in Africa.

## CHAPTER II.

### Establishment of feeder railways in all countries.

#### 1. General remarks regarding feeder railway systems.

The preceding chapter dealt more especially with the conditions relative to the establishment of penetration railways in the colonies; the present chapter will deal exclusively with the railways of the mother countries, the five European countries upon which we have been asked to report.

It appears to us necessary in this connection to take a rapid glance at the extent of these feeder railways in the five countries under consideration, and at the conditions under which they exist.

Of the five countries, Belgium is certainly that in which the network of secondary railways has attained the greatest development in proportion to the area. The lines at present in operation comprise a total length of 4 511 km. (2 803 miles), while a further 570 km. (354 miles) are either in course of construction or in contemplation. In France, on the other hand, where the system is from the point of view of length the most important, the total length is only 21 000 km. (13 050 miles) for a land surface approximately equal to twenty times that of Belgium.

In the three other countries the secondary railway systems are much less extensive. In Spain there are 3 891 km. (2 418 miles) and in Holland 1 248 km. (775 miles). We are not in possession of the figure for Portugal.

The Belgian system has one unquestionable advantage over the others, namely unified working. The law of the 28 May 1884, modified by that of the 24 June 1885, granted a monopoly to the *Société Nationale des Chemins de fer Vicinaux* (National Light Railway Company) for the construction of economic railways; other lines had, however, already been constructed, or concessions obtained, which have successively come directly or indirectly under the general control of the Société Nationale des Chemins de fer Vicinaux.

The laws which conferred this monopoly in Belgium may be regarded as a model in the sense that they gave the State, the provinces and the communes a common interest in the public utility undertaking this railway system formed.

In Spain a law of 30 July 1904 guaranteed payment of 4 % interest on the capital invested in the construction of these lines, and demanded no return from the lines so long as they had not reached an 8 % dividend level.

Since the world war, and in view of the general crisis which had also been felt in that country, the State took still further steps under the decree-law of 29 April 1927.

It grants capital subsidies which normally may not exceed 50 % of the cost of construction, but which may, in certain cases, exceed this limit. A part of these subsidies, up to as much as 75 000 pesetas per kilometre (120 700 pesetas per mile), is not repayable, the balance is repayable during the period of the concession, but subject to the results obtained. The concession may, further, be granted with a guarantee of interest payments.

It is not possible for us to go further into the details of this law, and we have not sufficiently detailed information with regard to the laws which at present govern the secondary railways of Holland and Portugal. In these countries, however, as we have already indicated, the secondary railway systems are not very extensive.

As regards France, we will merely recall that these railways have been the subject of a succession of laws, those of 1865, 1880 and 1913. The first left the entire risk and responsibilities to the concessionaires; the other two guaranteed payment of 4 % interest on the capital invested, but the company continued to shoulder all working risks.

It was found after the war that this legislation was not adapted to the conditions created by the new economic situation. The provisional regimes under which these concessions have existed since the war are gradually being replaced by new regimes of a more or less permanent character, and modifications in the law of 1913 have been under consideration for several years past.

One of the great weaknesses of the secondary railway system in France is the manner in which it is split up; the total 21 000 km. are divided up between nearly 200 companies, the most important of which, the Société Générale des Chemins de fer Economiques, operates only about 3 000 km.

## 2. Conditions under which they have been established.

Under what technical conditions have these railways been established

In Belgium, in general with metre gauge; certain lines with 1.435-m. (4 ft. 8 1/2 in.) gauge. Certain lines have three or four files of rails, thus allowing of the running of both metre gauge and standard gauge rolling stock.

The same remarks apply to France, but in this case certain railways still use the 0.60-m. (1 ft. 11 5/8 in.) gauge.

The information received from Holland, Spain and Portugal shows a similar state of affairs.

In the five countries under consideration the 1-m. or 1.067-m. (3 ft. 6 in.) gauge is that which has been the most generally adopted, with a view to reducing initial costs of construction, this having been, it would appear, the main preoccupation of the companies or authorities concerned when the various projects were under consideration. The replies which we have received on this subject are almost unanimous.

It appears that at the time when these lines were projected, only secondary importance was attached to the difficulties which might be experienced in regard to transhipment; unfortunately these difficulties, which were then only relative, have since increased in proportion to the increase in the cost of labour. To-day, in fact, as a result of legislative measures passed during the last ten years, the cost of the labour employed on our secondary railways has increased to a degree which is out of all proportion to other economic changes. In France, for example, while

the currency has depreciated to a fifth of its former value and the cost-of-living index figure has increased six times, the net cost of the labour employed by us is approximately ten times the pre-war cost in the case of unskilled labourers.

Thus the transhipment, which is nesessary at the points where the 1-m. or 0.60-m. gauge lines link up with the standard gauge lines, constitutes a heavy burden for all the administrations and hinders a transit traffic which tends to diminish with every year that passes. The measures which certain companies have endeavoured to take in order to remedy these difficulties, and in particular the installation of automatic transhipping equipment or the use of transporter-wagons, have only been very partially successful.

* * *

The initial capital expenditure on these lines varies between 50 000 and 125 000 gold-francs per kilometre (between 80 500 and 201 200 gold-fr. per mile), according to the difficulties encountered in each particular case. The figures are more or less similar for each of the five countries; in very rare instances the cost has worked out at somewhat less than 50 000 francs; in the case of certain other companies (generally companies operating standard gauge lines) the figure of 125 000 francs has been exceeded, but is would appear, from the information received, that in the case of all railways constructed before the war the average initial capital expenditure worked out at about 80 000 fr. per kilometre (128.750 fr. per mile) for narrow gauge line.

In Belgium the necessary capital has been subcribed in the proportion of 45 % by the State, 28 % by the Provinces, 26 % by the Communes and 1 % by private parties.

In Holland the initial capital has been provided entirely by the State.

In Spain it has generally been supplied, it would appear, by the companies themselves, under the guarantee of the State.

In France, under the régime instituted by the law of 1865, the companies have found the whole of their capital, and on completion of construction have received more or less considerable subsidies from the Departments, communes or private parties. The number of lines able to exist on their own resources has been very small. A number of them have failed and the large railways have absorbed others; not more than about a thousand kilometres still remain in operation.

Under the régime of the law of 1880, and that of 1913, which brought a partial State guarantee for the capital invested, the amount of capital provided by the Departments has been constantly increasing in proportion as the lines to be constructed have become decreasingly attractive as a financial proposition. At the beginning certain companies provided the whole capital; by 1913 the amount of capital required to be put up by the companies was in certain cases very greatly reduced, being little more than a deposit in the nature of security.

The Portuguese Railways have given no information in reply to this question.

### 3. Surveying and lay-out of lines and maintenance.

In the construction of these railways it would appear, as we have already suggested, that the principal preoccupation of the majority of the grantees was to economise on the first cost; the carrying out of this policy of economy has generally led to regrettable errors which have subsequently weighed heavily on the operating side. One finds, for example,

lay-outs with an excess of curves and reverse curves which it is difficult to explain today otherwise than as having been the result of a desire to reduce to a minimum the expenditure on the acquisition of land. This economy has generally been paid for dearly.

Similarly, in order to minimise the cost of earthworks, certain lines were constructed with such up and down gradients that the extra cost of traction thereby rendered necessary considerably exceeded the economies effected at the outset.

As a further example of the same error, the policy of economising in the land purchased by laying railway lines along the sides of roads has resulted in the existence of deplorable longitudinal sections wich have disastrous effects on the working today. Although such a policy might be reasonable in a flat country such as Flanders, and even, in such cases, more conveniently serve the various localities, it was obviously an error to adopt it in countries more broken. Lines like that from Rheims to Dormans on the Marne, which by deviating the route might have been constructed without any gradient in excess of 20 mm. (1 in 50), 25 mm. (1 in 40) maximum, actually has gradients of up to 45 mm. (1 in 22), which reduces the carrying capacity of trains by one-half and thereby doubles the cost of traction. A saving of this nature, which at the most could not amount to more than 10 000 fr. per kilometre (16 090 fr. per mile) has cost the administration more than 1 000 fr. per kilometre (1 609 fr. per mile) per annum.

Another error in the beginning was to equip these lines with rails which were too light, again for reasons of economy; this error has seriously limited the permissible weight of rolling stock and has made maintenance work more costly. It is certain that no lines would be laid nowadays with rails weighing from 15 to 18 kgr. to the metre, as was done in the past.

The standard rail in France for the metre gauge is the 20 kgr. (40.3 lb. per yard) rail, and certain companies have used rails of 25, 26 and even 30 kgr. (50.4, 52.4 and 60.5 lb. per yard). We have seen that in the colonies they have adopted even heavier weights for their penetration railways.

The principal change which has taken place in permanent way equipment on certain railways has been the adoption of concrete or steel sleepers in view of the high cost of timber sleepers.

The Camargue Railway Company, in particular, has made considerable progress in this direction. On almost the whole of this company's system the timber sleepers have now been replaced by concrete sleepers, which are made by the company itself at a cost not greater than that of timber sleepers. The first of these concrete sleepers were laid nearly twenty years ago, and on the occasion of the technical conference held by the « Union française » at Marseilles in 1927 we had an opportunity of remarking the perfect condition of these early sleepers. We must not, however, trespass upon the ground covered by Mr. Van Noorbeeck's most interesting report, which deals specially with this subject under Question XVIII [1].

You will see from that report that a number of French companies have in recent years experimented on a large scale with metal sleepers; none of these companies, however, with the exception of

(1) See *Bulletin of the Railway Congress*, October, 1929.

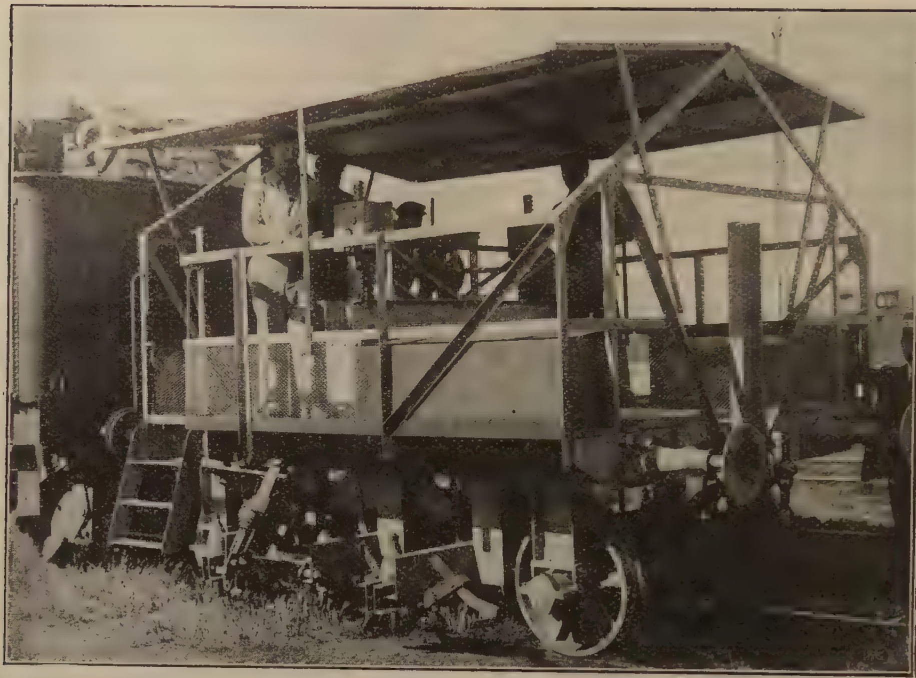


Fig. 12. — Mechanical track weeder « R. E. P. » of the Société de Désherbage et de Piochage du Ballast des Voies ferrées. — General view.

the Corrèze Railways, has yet been able to form any final opinion on the subject. We may add that the Corrèze Railways appear to be very satisfied with this type of sleeper. It would appear also that these sleepers have given satisfaction in various other countries.

Although a metal sleeper necessarily costs somewhat more than an impregnated timber sleeper, it has apparently a longer life; it also appears to be a fact that a line equipped with metal sleepers has greater stability and entails less labour for maintenance. The Railway Union (« Union des Voies ferrées ») of France has standardized certain types which, together with the sleepers in use on the Camargue Railways, you will find described in the report by Mr. Van Noorbeeck.

As regards maintenance work, the companies obviously desire to organise it as economically as possible. Certain companies have adopted the practice of concentrating their platelayers at a single centre, as has also been done by certain of the large railway administrations for their secondary lines, and to despatch them, either by train or trolley to the spot at which their services are required, thereby lengthening the sections and reducing not only the number of gang foremen but also the total number of platelayers as a result of the more efficient organisation thus attained.

The weeding of the track also presents

a problem for the railway administrations; the expenditure on labour engaged in this work is today particularly high. Various chemical processes have been resorted to with a view to reducing this expense, but most of them are still expensive in themselves and not too effective. Experiments have been in progress for some time past in mechanical weeding, but the cost of this method is relatively high and it is too soon to express an opinion as to its efficacy. We think, however, it may be of interest to reproduce a diagram of the machine which has been used on the Côte d'Or Railway and the line from Guë to Menaucourt (France).

#### 4. Traction and rolling stock.

We now come to questions 12, 13 and 14, in connection with which we have endeavoured to ascertain the technical conditions under which these railways operate.

In the first place, to what extent is electric traction found on these railways? According to the figures supplied to us, this method of traction is still quite rare on light railways, due largely to the infrequency of the trains.

In Belgium only 600 km. out of a total of 4 500 km. have been electrified; in Holland steam traction is still universal. We have no information in regard to electrification of light railways in Spain and Portugal. In France only three light railway systems of any importance have been electrified : the Railways of Provence, the Railways of the Haute-Vienne and the Railways of the Camargue. The subsidiaries of the Midi Railway (France) have a few lines under electric traction; the Northern Light Railways have electrified their Valenciennes system. As a whole,

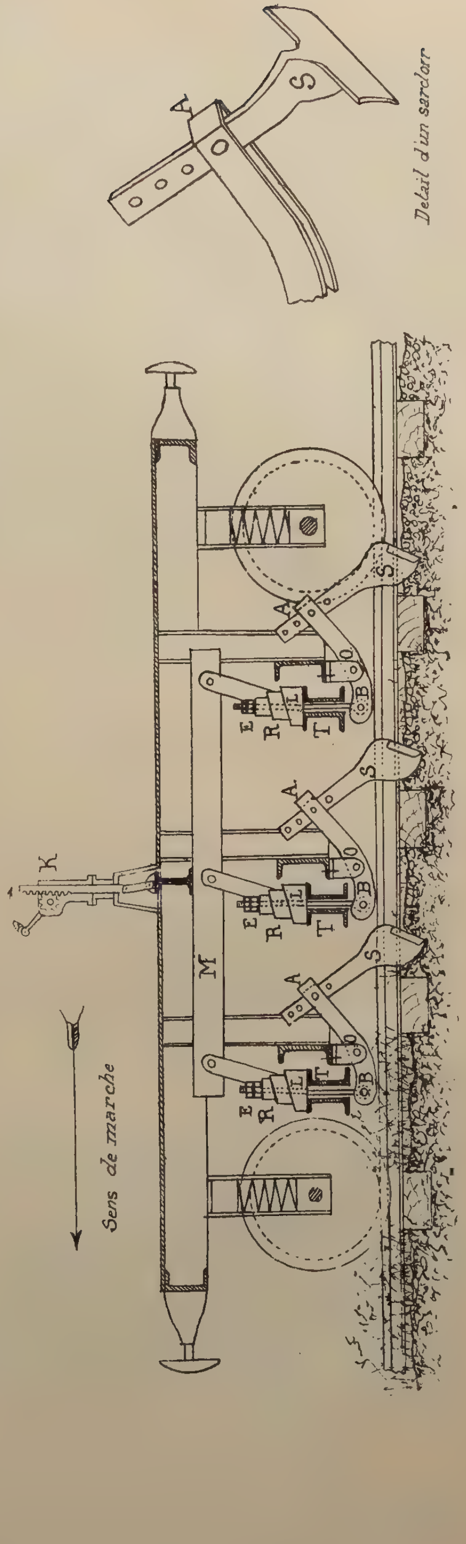



Fig. 13. — « R. E. P. » mechanical track weeder. — Diagram shewing hoe mechanism.

*Explanation of French terms* : Détail d'un sarcloir = Detail of one hoe. — Sens de marche = Direction of running.

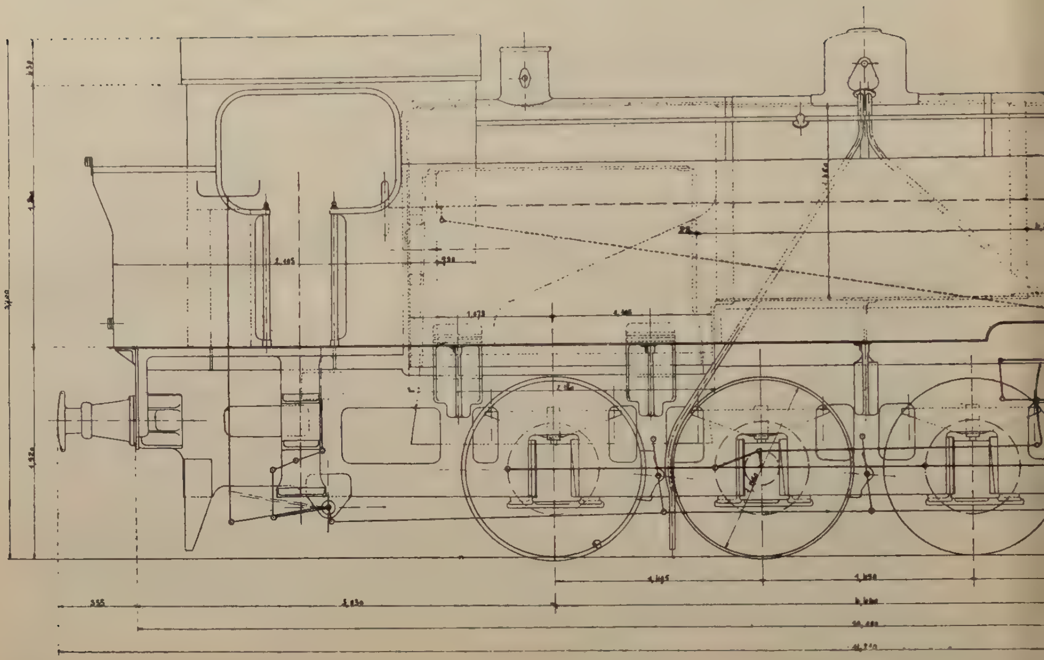


Fig. 14. — North-Eastern Light Railways

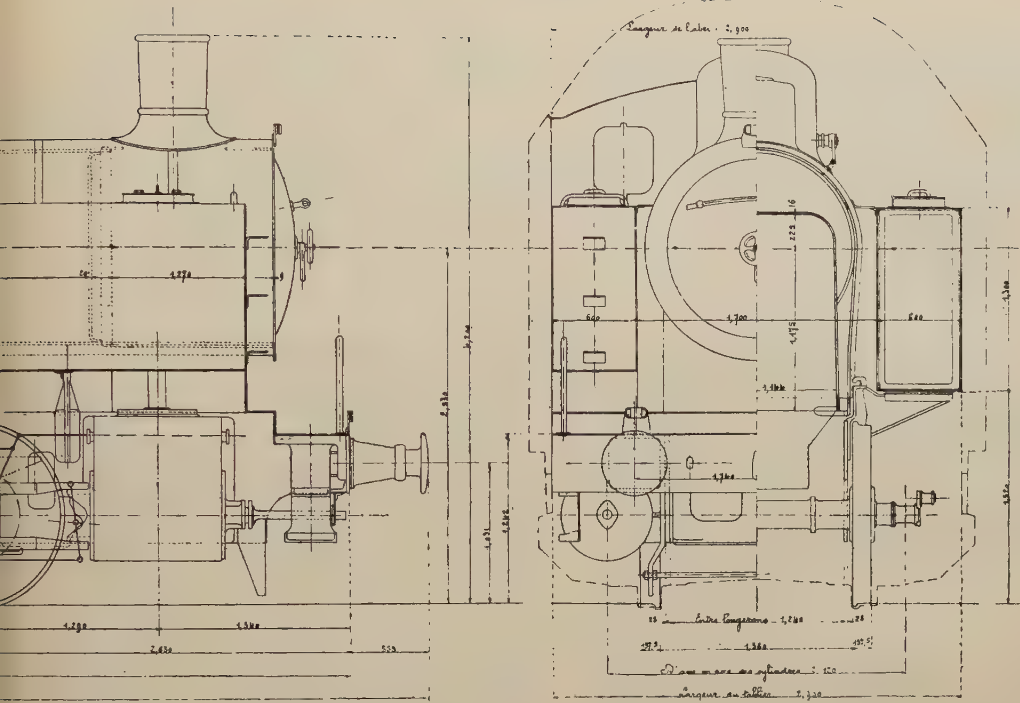
*Princi*

| | | | |
|---|---|---|---|
| Diameter of cylinders | 0.480 m. (18 7/8 inches). | Tubes | Distance betw plates |
| Piston stroke | 0.660 m. (26 inches). | | External diamet |
| Diameter of wheels | 1.260 m. (4 ft. 1 19/32 in). | | Number |
| Effective boiler pressure, kgr. per cm². (lb. per sq. inch) | 12 kgr. (170 lb.) | Heating surface | Of firebox |
| Grate — Length | 1.998 m. (6 ft. 6 11/16 in). | | Of tubes (avera ter) |
| Grate — Width | 1.144 m. (3 ft. 9 inches). | | Total |
| Grate — Surface | 2.28 m² (24.54 sq. feet). | | |

however, in all these countries steam remains the method of traction most generally adopted.

At the same time it should be added that, particularly in France, steam traction railways have for some years been experimenting with motor coaches using either petrol or heavy oil, with a view to reducing working expenses. The results of these experiments have not always been as satisfactory as could have been desired. Two reports have, however, been presented, one on the application of electric traction to light railways and the other on the use of motor coaches. Here again we do not wish to encroach upon a sphere which will be covered by Messrs. Sekutowicz and Beghin, the reporters on Questions XIX and XX.

As regards the engines employed for



coupled tank engine. — General diagram.

*stics.*

| | | |
|---|---|---|
| | Water supply . . . . . . . . . | 9.400 $m^3$ (2 070 British gallons). |
| 50 m. (13 ft. 11 5/16 in.) | Fuel supply . . . . . . . . . | 3.250 $m^3$ (114.7 cubic feet). |
| 50 m. (19 11/16 inches). | Approximate weight — Running light . . . | 48 000 kgr. (105 800 lb.) |
| | Approximate weight — In working order (with |  |
| 8 $m^2$ (102.04 sq. feet) | max. supplies) . . | 64 700 kgr. (142 640 lb.) |
| | Tractive power on the formula : | |
| 8 $m^2$ (1 255.98 sq. feet). | $\frac{0.65\ pd^2l}{D}$ . . . . . . . . | 9 415 kgr. (20 760 lb.) |
| 6 $m^2$ (1 358.02 sq. feet). | | |

steam traction, it does not appear, from the documents which have been submitted to us, that any striking progress has been made on these railways in recent years. Very little rolling stock has, indeed, been constructed for these lines during the last fifteen years. A certain number of administrations have, however, begun to use more powerful engines on their busier lines, in order to be able to reduce the number of trains. Articulated engines weighing 40 metric (39.4 Engl.) tons are in use in France on the metre gauge lines of the Economic Railways, the Departmental Railways, the Corrèze Railways and the North-Eastern Railways; these railways also use, on their standard gauge lines, 60-ton (59 Engl. tons) engines capable of hauling a load of 400 metric (394 Engl.) tons over 15 mm. gra-

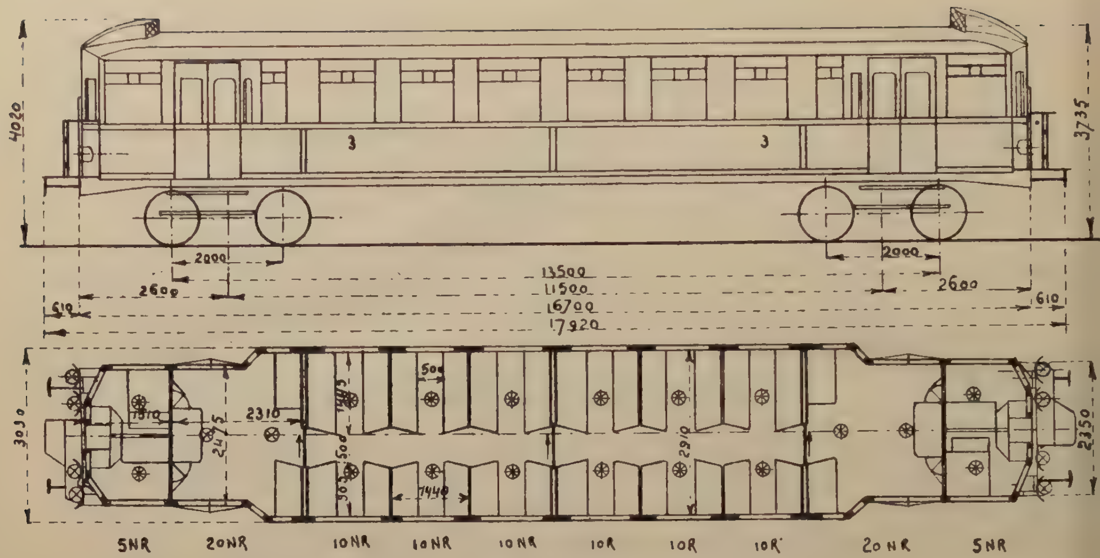



Fig. 15. — Netherlands Railways. — 3rd class motor coach for narrow gauge lines. Accommodation for 110 passengers. — Tare weight: 32 000 kgr (70 550 lb.).

dients (1 in 67) and 1 200 t. (1 181 Engl. tons) on the level.

These examples are, however not very widely imitated, because there are, unfortunately, very few lines whose traffic is sufficient to justify the use of such engines; they would, moreover, be limited by the permanent way, which would not therefore continue to use light engines being used. The majority of companies therefore continue to use light engines, which consume little fuel, and the types of which have already been described. Certain companies have obtained permission to man these engines with a single employee in order to reduce running expenses. Those companies which have begun to run motor coaches are, for the same reason, also beginning to run them with a single employee, who combines the duties of driver and ticket collector, following the example set by a number of tramway companies.

The newest carriages are undoubtedly an improvement from the point of view of comfort, particularly as regards heating and lighting; the antiquated footwarmer is disappearing, being replaced by a heating system fed by steam or hot air. Electric lighting is gradually replacing the old paraffin or heavy oil lamps, thereby combining economy with greater comfort for the travelling public. The solution most widely adopted appears to be to place the dynamo and the battery of accumulators in the guard's van.

Finally, most companies are gradually generalising the use of bogie carriages, as being not only more comfortable for the passenger but less severe, on the line.

The capacity of goods wagons recently built also shows a slight increase. In this the light railways are following the example set by the standard gauge railways.

### 5. Present financial situation of these railways.

In general the authorities who have sunk capital in these undertakings attach relatively small importance to what their investment may yield. Their main object has been to assist in increasing the economic prosperity of the region whose interests are entrusted to their care. Naturally, this attitude could not be shared by the companies. When shareholders have invested their capital in an undertaking, it has been in the hope of receiving a reasonable return on their investment. They themselves guarantee such a return to the debenture holders who have contributed their share towards the cost of construction of the railways. It is, therefore, the first duty of the administration to balance their budget, and this can only be achieved if receipts can be made to cover expenses or, failing this, if subsidies are forthcoming from interested authorities.

Even before the war many administrations had the utmost difficulty in squaring their budgets. How much more difficult is that task to-day ! To questions 11 and 12, which deal with this subject, we have not received the full answers which we could have desired.

However, to the question : « Are you able to balance your budget of expenses and receipts? » the Société Nationale des Chemins de fer Vicinaux (Belgian Light Railway Company) replies : « Yes, for almost all our lines, but not all; if, however, the total capital of all the lines, were pooled (each line at present having an independent capital), the general budget would be in equilibrium ».

This shows a healthy state of affairs. It is due to the density of the population and to the highly developed industrial character of Belgium. A similar situation is reported by the Dutch Railways. On the Spanish Railways, as a whole, the net yield has almost doubled.

In France, on the other hand, although certain lines show a profit, after allowing for debenture interest and a reasonable dividend on capital, we are obliged to report that the number of such lines is extremely small. It is estimated that for the last ten years not more than one-tenth of the French light railways have had receipts equal to their total expenses: the minority is composed chiefly of those lines which were constructed on concessions sanctioned by the law of 1865 and which have continued to exist under that régime; these are the oldest concessions, and were granted at a time when the construction of a railway would not even be mooted unlesss it was certain to cover its expenses and pay dividends on the capital invested.

It may be well to remark here that certain railways, which might otherwise have been in a position to balance their budget at any time during the last ten years, have not been able to do so because the authorities under whose control they were, have refused to allow increases in tariffs proportionate to the increased cost of labour and materials.

The result has been that undertakings which might have been self-supporting if allowed to charge adequate rates, have had to depend on the authorities for financial support.

There is a general tendency in France at the present day to correct these unfortunate errors, but this regrettable policy has proved a heavy burden to certain departments and certains towns.

It appears, further, from the replies received to the ninth question (« How and to what extent is a return paid on your capital? ») that the present return

is generally less in absolute values than it was before the war in countries which have a depreciated currency.

The same does not apply in countries with an appreciated currency. In Spain, for example, although the total length of line only increased from 3 024 km. in 1914 to 3 891 in 1926, net profits increased from 15 322 000 pesetas in 1914 to 26 942 000 pesetas in 1926. The railway traffic of the country showed a very marked increase during the period; gross receipts increased from 39 962 000 pesetas in 1914 to 92 842 000 pesetas in 1926, while expenses increased during the same period from 24 640 000 to 65 900 000 pesetas. Both passenger and goods traffic have contributed to this considerable increase.

In France the yield on capital is generally at the same nominal figure as before the war, but in view of the currency depreciation the real yield is only one-fifth of what it was before the war. In too many cases, and without any justification, departments and towns endeavour to limit increases in rates to such an extent that it is quite impossible for the railway companies to show any higher return on capital. In certain cases, indeed, a company is obliged to charge lower rates on a narrow gauge line than those which are applied to the standard gauge lines, although the users of the narrow gauge line could well afford to pay on the higher scale; and all this to prevent the company from showing a nominal return in paper-francs higher than that which it showed before the war in gold-francs.

One can truthfully say that this industry is one of the least favoured in our country. Ordinary industrial enterprises have succeeded in overcoming the effects of the economic crisis, and a number of them are now paying higher gold-franc dividends than before the war; gas and electricity undertakings have been authorised to charge rates which will allow them to pay dividends practically equal to those paid up to 1914. The narrow railways alone are reduced to this practically hopeless situation, a situation which would certainly scare away the capitalist if it became necessary to appeal to him for assistance in new constructional work. The latter question does not, however, arise for the moment, as we shall see presently.

* * *

We should like to have been able to give a comparative table of the average receipts per kilometre for the feeder railways in the five countries in question, and a similar table for expenses, distinguishing between the three sections : operation, traction and permanent way Unfortunately the information supplied to us is wholly inadequate for the purpose.

### 6. Construction of the new lines.

Is the construction of any new lines contemplated in the five countries under review?

If so, to what extent; and what improvements are to be anticipated as a result of past experience and the development of railway technique in modern times ? This is the subject of Questions 15 and 16.

The generally accepted view is contained in the opinion expressed by the Dutch State Railways : The possibility of the construction of new lines is very limited ». This opinion is shared by the Spanish Railways, who add, however, that the question of new constructions might arise as regards regions where there

would be no possibility of economic development in the absence of such lines of communication. In general, however, this would only apply in the case of poor regions in very broken country; the costs of construction would be very heavy and the lines not very productive. The Spanish Government would, however, be prepared to consider the construction of such lines : It does not appear that the question arises in the same way in the four other countries consulted.

The following are the remarks we have received on this subject :

The Belgian Light Railway Company states that 570 km. (354 miles) of railway line are still under construction or contemplated; the French Railways report about 500 km. (310 miles) and the Dutch Railways 63 km. (39 miles). We have no figures for Spain and Portugal, but it appears that the opinion in the Iberian Peninsula is the same as in the three other countries. One of the Spanish companies, for example, states :

« Our experience of this question leads us to consider that the feeder lines at present linked up with our main railway system are the only feeder lines which could exist in our country with any possibility of success. »

The Dutch Railways remark :

« New lines are no longer constructed to any appreciable extent », and this statement more or less summarizes the replies of the French Railways in general; the construction of narrow gauge railways in France has practically ceased.

In France a further problem has been encountered, and has already been partially solved, namely the closing and disposal of unproductive lines. Certain lines which were constructed in the years immediately preceding the war of 1914 owed their existence more to political and electoral motives than to any prospect of ever carrying sufficient traffic to enable them to show a reasonable return on the capital invested. As a result of the economic chaos which followed the war, their deficits increased to such an extent as to render their continued existence injustifiable, reaching in some cases more than 10 000 fr. per kilometre (16 090 fr. per mile). Moreover, the motor transport services, to which we shall refer later, were quite capable of replacing them with advantage. According, since 1919, no less than 33 lines or sections of lines, of a total length of 416 km. (258.5 miles) have been abandoned.

It would thus appear that in France too many feeder lines have been constructed in the past, and that the present tendency, therefore, is to demolish rather than to construct.

As regards improvements wich may be introduced in the construction of such new lines as are projected, we see references, in the replies which have been given to us, to the use of more powerful engines, with superheating. The European countries and Algeria refer to the more general use of bogie carriages. The « Société Nationale des Chemins de fer Vicinaux » (Belgium) is of the opinion that the present types of rolling stock are sufficiently satisfactory.

As regards the track, some companies contemplate the use of heavier rails (Vendée, Indre, Algeria, and others of metal sleepers (Corsica). The Belgian Light Railway Company advocates welded joints, either all the joints (for track set in paving), or two joints out of three, or three out of every four.

We would repeat, however, that the general impression is that very few new lines will be constructed, and that (Spain

excepted) the feeder line seems to have reached its limit of development in the European countries.

### 7. Causes of the cessation of construction.

What then are the causes of this almost general suspension in the construction of feeder lines wich had been in contemplation in 1914, and what are the causes of the obsolescence of a certain number of existing lines?

This appears to us to be the most vital question at the moment for the European railways and one which should receive our particular consideration, in view of the repercussions which it must eventually have upon our various administrations.

Obviously the economic upheaval which resulted from the war had a considerable influence upon the working results of undertakings which were already in a precarious condition prior to the war. As I pointed out at the beginning of this report, the item « Labour » has been responsible for a very serious addition to our burdens. In all countries great improvements have been made during the last fifteen years in the lot of the working class : family allowances; pensions; insurance against sickness, unemployment, etc.; and, finally, the most heavy burden of all for industry, the introduction of the 8-hour day.

These improvements have undoubtedly been admirable from a humanitarian and social point of view, but they have resulted in increased costs of production with a consequent increase in selling prices and in the cost of living generally.

Unfortunately our railways have not been allowed to increase their tariffs in proportion to this general increase; they have in the first place been prevented by the authorities interested, for general political reasons, as I have already indicated; but even had they not been restricted by these authorities themselves, another factor existed which would in most cases have prevented them from raising tariffs proportionately to the increase in the cost of living, and that factor is the development of motor transport. On the one hand, the number of private cars rapidly multiplies, so that in localities which are at some little distance from a railway, or from the town from which supplies and provisions are obtained, there is an ever increasing number of rural inhabitants who formerly made use of the local feeder railways but who now use their own car for these journeys. A second and even more important development is the springing up in all directions of public motor transport services, too often in direct competition with our own small lines and gaining favour with the public because they better serve the villages and in general convey passengers more quickly to their destinations throughout the countryside.

Finally, the motor lorry is a serious competitor for the narrow gauge lines where transport has to bear the extra charge of transhipment; the lorry, which picks up the goods at any desired spot and carries them direct to the main line railway station, often works out much more cheaply for the despatcher than the three distinct operations involved in the use of the narrow gauge railway : carriage to the small local station, carriage to the transfer station, and transhipment.

In this connection we think it well to reproduce the statement received from :

1. The Midi Railway of France;

2. The « Société des Transports en Commun de la Région parisienne », in so far as this question concerns the suburbs of a capital city.

*Midi Railway of France.*

It is very difficult to estimate, even approximately, the amount of traffic which we have lost through motor competition, for in order to do so it would be necessary to know the figures for motor transport, and these are rarely available, as the owners or contractors will not divulge them, either in order to avoid the competition which might be brought against them, or so that the fiscal authorities shall not know the full extent of their profits.

We did, however, attempt, in 1925, to make an approximate estimate of the diminution in traffic directly attributable to motor transport competition, and we arrived at the conclusion that through this form of competition we had lost in the neighbourhood of 2 100 000 fr. on passengers (or 1.2 % of total passenger receipts), 93 000 fr. on parcels (or 1.7 % of total luggage receipts) and 490 000 fr. on goods (or 0.1 % of total goods receipts).

To these figures must be added the losses which have resulted from the fact that certain traders now provide their own means of transport. In 1925 at least 800 industrialists or tradesmen were using motor lorries. The area served by them is extremely variable, in some cases not going beyond the immediate surroundings of a locality, and in others extending for a hundred kilometres or more (furniture and general stores, wholesale grocers, etc.). We estimate that in 1925 the loss which we suffered owing to this form of competition was about 6 500 000 fr., or 1.7 % of slow goods receipts.

Motor transport competition increased still further between 1925 and 1928. On the 1 January 1928 the total length of the motor routes in the areas served by our railways was 2 839 km. (1 764 miles) for daily motor services and 3 859 km. (2 398 miles) for periodical motor services.

The length of our lines exposed to this competition was 2 725 km. (1 693 miles). The prosperity of the motor undertakings is still further augmented through the fact that they are often generously subsidised and the taxes paid by them are very low.

In view of the fact that railway transport has to bear heavy taxation (particularly the 32.5 % on passenger rates), the State treasury receiving more than 2 milliards of francs in 1927 from the country's system of main railways, it is illogical and contrary to the national interests that the authorities should lend their financial aid to competing enterprises, which are already unduly favoured by the relatively low charges which they have to bear.

*Société des Transports en Commun de la région parisienne.*

Motor transport competition is twofold.

As regards passengers, the increase in the number of automobiles in circulation in the Seine and Seine-et-Oise Departments must inevitably have a regrettable effect on railway passenger traffic. It is, however, impossible to estimate to what extent.

As regards the transport of goods (consisting principally of market garden produce consigned to the central markets at Paris), motor transport competition has made itself felt to such an extent that we have had to organise our own motor transport service to supplement our railway goods service.

Few of our companies have been able to arrive at any exact estimate of the loss suffered by them from this competition, though the Vendée Railways estimate their loss in passenger traffic at 35 %, while the Algerian State Railways state that their loss varies between 50 and 100 % for transport over distances below 50 km. (31 miles).

8. The future of feeder railways.

What are companies doing in face of this situation?

The question is under consideration in Belgium. Its importance does not appear to be so vital in Spain as in the other countries.

In Holland there appears to be a tendency in the direction of the organisation of subsidiary motor transport companies by the railways; and the same policiy has been followed by the French companies for the last two years, each of the seven large companies having formed a motor transport organisation with the collaboration of the narrow gauge railways of their respective areas. It is hoped by means of these organisations to limit competition and thereby mitigate its disastrous effects. In any case, the profits which the railways will derive from their own motor transport services will offset to a certain extent the losses sustained by reason of competition from independent motor transport. It is premature to endeavour to forecast the results which these organisations will achieve, but what is certain is that a large number of existing feeder railways would never have been constructed if at the time they were under consideration one could have foreseen the results obtained today with motor transport.

We have pointed out above that in France the more unproductive narrow gauge lines are in process of being eliminated; other countries are contemplating adopting the same policy, the companies and autorities concerned seeing no alternative in the case of lines which show large deficits. In France, where this question has become more imperative than in the four other countries with which we are concerned, the consequences of the present situation are for the most part necessarily borne by the Departments, and they cannot continue indefinitely burdening their budget with the ever increasing deficits of lines which can never hope to regain financial equilibrium.

Certain Departments have endeavoured to find a solution in the nature of a compromise, transporting passengers by road and retaining the rail for the transport of goods. These do not seem to be more than partial solutions, and they can only be applied in particular cases. In the majority of cases in fact, if such a solution is to be a success there must be a saving on the cost of maintenance of the line, but this means that in a few years' time even goods traffic will be unable to run efficiently unless considerable expense is incurred on renewals. In reality, if the volume of goods traffic is sufficient to justify the continued existence of the railway line, it would seem that the use of light motor coaches should not be more costly than the running of motor buses. The policy to be adopted must, however, depend on the circumstances of each particular case. In some cases the railway route is so sinuous that it may be advantageous to resort to the motor bus rather than to the railway motor coach; in other cases the junction of the light railway with the main line may lie at some distance from a large town, in which case it will be more convenient to transport passengers by road from the various localities to the town direct.

Measures such as we have just indicated cannot, however, be considered as likely to be generally adopted in the future. If they prove inevitable in the case of lines which follow an inconvenient route, or which ought never to have been built in view of the small volume of traffic to be expected, the fact remains that

the large majority of our feeder railways retain an undoubted value. Our efforts must, therefore, tend towards improving their working conditions, so that they may be enabled to survive in spite of the difficulties created for them by the various factors to which we have briefly referred above.

Whereas the Dutch Railways remark :

The development of motor traffic being closely bound up with the improvement of the roads, which in turn progresses only very gradually, it is not possible for us at the present time to give a definite opinion as to the future reserved to the feeder lines of the large railways of our country,

The Belgian National Light Railway Company, on the other hand, writes :

If the lines are to retain their « raison d'être » from the financial point of view, we must, in order to withstand the competition of the now popular motor bus services, aim at modernisation, whether by electrification or by the adoption of other methods which will enable us to transport passengers to their destination with the maximum of speed, comfort and economy.

Finally, in the same connection we ought to quote the more optimistic opinion of the Manager of the Railways of the Ain Department of France :

I consider that the crisis through which light railway and tramway companies are passing at present should not deprive them of any of their future usefulness, provided that their organisation can be adapted to the new economic situation.

Our railways have suffered from a too sudden reversal of previously accepted ideas and from the development of the motor industry.

If the war had not happened they would have adapted themselves gradually to gradually changing conditions. The war hastened the evolution of habits and customs, while tramways remained what they were.

Obviously our tramways are today suffering from the growth in the number of automobiles, whether lorries, private cars or motor buses. This situation will not last : automobiles will continue to multiply, but once the tramways have learnt what must be their new orientation they will regain their clientele and will progress, however numerous the automobiles become.

The man who possesses an automobile, whether he be a commercial traveller, a business man or a private citizen, only uses it at present because the tramways are unable to render him the same service. The tramways believed, at the commencement of the crisis through which they are passing, that salvation would lie in reducing the number of trains; this was a mistake, and it is this mistake which compels the owners of automobiles to use them.

If a speedy and frequent tramway service enabled these automobile owners to go about their business without wasting their time in or waiting for trains, they would not use their automobiles, which cost them much more per kilometre; they would limit their use to journeys which could not be made by tramway or to pleasure excursions, and they would all the more surely do so as there is a movement on foot in political spheres for making automobile users pay (in a manner yet to be determined, but either by direct taxation or indirectly by a tax on petrol) what they should normally pay if one makes a comparison with railway passengers, who are subjected to a tax which, in the case of the main railways, amounts to 33 %.

If tramway undertakings are to survive, therefore, they must improve their

service in at least two respects: the speed and the frequency of running.

In order to realise such a programme there must be a reduction in costs of operation per train-kilometre and, in particular in the cost of traction. On this point I consider it impossible to express any opinion of a general nature; each administration must examine its own geographical, physical and economic situation.

* * *

In conclusion, we consider that the majority of our feeder railways still have hopes of prosperity if they will adapt their organisation to the present general transport situation and if governments will give them assistance in two principal ways:

1. Allow them to apply, without unnecessary and vexatious restrictions on the part of the local authorities concerned, the tariffs which the public can well afford to pay;

2. Regulate motor transport and in particular public transport services, so as to limit the effects of a form of competition which at the present day acts only too often to the detriment of the community as a whole.

In our opinion these questions deserve special consideration at a future Congress.

APPENDIX.

## List of Companies who replied to the Questionnaire.

**Belgium and Colonies.**

Belgian National Light Railway Company.

Upper Congo to the Great African Lakes Railway.

**Spain.**

Agnalcollar-Guadalquivir Railway.
Arriondas-Covadonga Railway.
Asturian Light Railways.
Mollerusa-Balaguer Railway.
Ponferrada Mining Railway.
Rio-Tinto Mining Railway.

**France, Protectorates and Colonies.**

Midi Railway.
Paris-Orleans Railway.
Departmental Railways.
Ain Departmental Tramways.
South-Western Railway.
General Light Railway Company of France.
Société des Transports en Commun de la Région parisienne.
Indre Tramways.
Vendée Tramways.
Algerian State Railways.
Algerian Railways of the Paris-Lyons and Mediterranean Company.
French West African Colonial Railways.
Dahomey Colony Railway.
Ivory Coast Railway.
Conakry-Niger Railways.
French Railway Company of Dahomey.
Tangiers to Fez Franco-Spanish Railway Company.
Indo-China and Yunnan Railways.
Moroccan Railway Company.
Tunisian Railway Company.
Thiès-Niger Railways.

**Holland.**

Netherlands State Railway Company.
Dutch Railway Company.

**Portugal and Colonies.**

Portuguese Railway Company.
Sao - Thomé Railways (Portuguese State).

[624 .63, 625. 142.4 & 721 .9]

# REPORT No. 3

**(All countries, except America, the British Empire, China, Japan, Belgium, France, Italy, Portugal, Spain and their Colonies and Switzerland)**

## ON THE QUESTION OF THE USE OF CONCRETE AND REINFORCED CONCRETE ON RAILWAYS (SUBJECT I FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1) (2),

By E. KRICK,

ENGINEER, INSPECTING OFFICER AT GENERAL HEADQUARTERS OF THE STATE RAILWAYS OF THE KINGDOM OF YUGOSLAVIA.

### I. — Reinforced concrete sleepers.

The idea of making railway sleepers in reinforced concrete is as old as reinforced concrete itself. Monier proposed to make this use of the new material when applying for his patent in 1877. The first practical tests of reinforced concrete sleepers in railway permanent way were not however carried out until some years later.

Naturally those railway companies who had to import the wood required, or those owning lines running through districts in which wooden sleepers decayed quickly, had especial interest in using a practical and cheap reinforced concrete sleeper.

It is therefore not surprising that the management of the railways in the countries dealt with in this report and which with few exceptions still possess extensive supplies of timber have not yet carried out on a large scale tests with reinforced concrete sleepers, because no economic advantage was to be expected in this direction up to the present time.

The Danish State Railways report that the tests with reinforced concrete sleepers mentioned in the preliminary papers for the Rome 1922 Session, Volume 1. Question IV, Report No. 7 (*Bulletin of the Railway Congress* for January 1922, pp. 25 et seq.) has not been continued. Out of the 2 000 sleepers in reinforced concrete laid in 1905 on the principal lines, about 700 are still in service, from which it may be concluded that their average life is 18 years.

As this management does not propose for the time being to make further tests with sleepers of this kind it would seem that the results obtained were not satisfactory from a technical point of view, or that at the present time it is still more economical to use wooden sleepers in Denmark.

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(1) This question runs as follows : « The use of concrete and reinforced concrete on railways :

*A.* — Investigation into the respective merits of the different designs of concrete sleeper.

*B.* — Concrete and reinforced concrete buildings. »

(2) Translated from the French.

As regards the other countries we have received only one reply, and that moreover, a brief one, from the Czechoslovakian State Railways on which tests have been made with reinforced concrete sleepers similar to the well known Italian type and which have only been laid in lines near locomotive depots and consequently run over at low speeds. But as these tests have not yet been carried out on a large scale, nor over a lengthy period the Administration has not been able to supply definite information upon the economic and technical value of these sleepers.

In view of the insufficient information upon the use of reinforced concrete sleepers on the Railways dealt with in this report, we have not been able to formulate any conclusion upon the advantages or drawbacks whether economical or practical of this form of construction.

## II. — Structures in concrete and in reinforced concrete.

### A. — Bridges and culverts.

In the case of culverts of up to 2 m. (6 ft. 6 3/4 in.) span formerly only supporting timbers were used, and these have been replaced by reinforced concrete slabs.

According to the replies received from the different Administrations use is made of slabs reinforced with round bars when covering over waterways up to 3 m. (9 ft. 10 1/8 in.) span.

Sometimes also when the available height of the structure is small the slabs of this kind are reinforced with old rails or I sections in steel.

Whereas if old rails are used the opening of the waterways to be covered is limited to about 3 m. From the replies from the Finnish State Railways, the Guillaume-Luxembourg Railways, the Czechoslovakian State Railways, and the Yugoslavian State Railways, it would appear that I section girders embedded in concrete can also be used for larger openings up to 10 m. (32 ft. 9 3/4 in.) as a maximum.

In all these cases in which the reinforcement of the slabs is formed by old rails or by I section girders the concrete is considered as filling, and the rails and the girders are taken as carrying the whole of the permanent load and of the live load. These reinforcements are bound together by round iron stirrups or by being bolted together.

As support, a rail embedded in concrete in the abutment and well anchored is preferred.

Nearly all the Administrations report existing applications of girder slabs (ribbed girders in reinforced concrete) under railway lines. On standard gauge lines as a rule 4 ribbed girders per track are used, that is 2 per rail, and in special cases 3 girders; for narrow gauge lines the number of ribbed girders per track is generally 2 only. According to the replies from some Administrations this type of construction has been employed for bridges of up to 10 m. (32 ft. 9 3/4 in.) span.

As regards the question of saying up to what span such construction can be considered economical most of the Administrations replying state that the maximum is from 10 to 12 m. (32 ft. 9 3/4 in. to 39 ft. 4 1/2 in.); one Administration alone is of the opinion that the span may reach 20 m. (65 ft. 7 3/8 in.) upon the main lines and 25 m. (82 ft. 1/4 in.) upon secondary lines.

As regards the form of the bearing for the girder slabs, the opinions of the various Administrations are divided.

Whereas some are satisfied to place tarred paper upon the supports, the Egyptian State Railways and the Guillaume-Luxembourg Railways use lead sole plates and the Bulgarian State Railways, when the span exceeds 8 m. (26 ft. 3 in.), the Swedish State Railways, and the Yugoslavian State Railways use steel friction plates while the Danish State Railways and the Finnish State Railways are of the opinion that for structures of this kind the bearing should be formed of slides or rollers as in the case of steel structures.

Structures similar to girder bridges in reinforced concrete with lower decking have only been used by one single Company: the Danish State Railways; the span is about 22 m. (72 feet).

However results were not satisfactory as cracks and flaking away of the concrete occurred at the connections and had to be repaired.

All the Administrations have pointed out the need for a sufficiently deep layer of ballast above the reinforced concrete structure.

As the minimum distance between the top of the structure and the lower edges of the sleeper 20 cm. (8 inches) are sometimes required. Most of the Administrations are however of opinion that the distance should be about 25 cm. (10 inches), and a small number only such as the Dutch and Swedish Railways consider that the distance between the structure and the sleeper should be at least 30 cm. (12 inches) and should even be as much as 35 cm. (14 inches).

No Administration considers that the rails or the sleepers should be laid directly upon the structure.

In the case of a light railway bridge also used at the same time as a road bridge, the Egyptian State Railways have laid the rails directly upon the structure simply inserting a 5 mm. (3/16 inch) thick lead sheet between them and without using any arrangement of fastening. In order to keep the gauge to the correct figure the rails which are of the Vignoles type are tied together transversly by iron plates 50 × 15 mm. (2 inches × 5/8 inch), as in the case of tramway lines.

This Administration however formally states that arrangements of this kind cannot be recommended.

In the same way for small culverts, owing to the lowness of the structure, the Dutch East Indies State Railways have laid the rails directly merely using ordinary iron bearing plates on the structures, the reinforcement of which consisted of ordinary rails and in which the wood ferrules were cast in place. The rails are fastened down by clips and coach screws. This Administration also has declared that the method of allowing the rails to bear directly upon the structures is a bad one.

As regards larger structures of this kind the different Administrations have sent in the following replies :

The Bulgarian State Railways have built two arch bridges in reinforced concrete each of 40 m. (131 feet) span.

The Danish State Railways have built reinforced arches up to 15 m. (49 ft. 2 1/2 in.); they have in addition built a double track bridge of 43.80 m. (143 ft. 8 in.) length in 5 bays in the form of a continuous girder framed into the intermediate supports. The supports at their lower ends have been given the form of incomplete hinges with lead bearing plates 20 mm. (13/16 inch) thick and 3 vertical round iron bars 30 mm. (1 3/16 inches) in diameter to secure the bearings. The abutments carry the girders, that is to say 3 ribbed girders per track

each on a steel roller between steel plates which ensure the perfect freedom of the girders. The result is satisfactory.

The Finnish State Railways have so far only dealt with arch bridges of small span and are very satisfied with the results.

The Alsace and Lorraine Railways point out that the Guillaume-Luxembourg Railways have recently built an arch bridge of 33 m. (108 feet) span with suspended deck; they cannot however express any opinion upon the results as the bridge has been in service too short a time.

The Norwegian State Railways have built bridges of up to 6 m. (19 ft. 8 1/4 in.) width as plain reinforced panels. In one case the abutments of a metal railway bridge of 8 m. (26 ft. 3 in.) length have been built in the form of plain panels 2 m. (6 ft. 6 3/34 in.) in width and the openings have been used by the road covered over. Along the centre line of the railway an expansion joint is arranged so as to make each line quite free. The retaining walls parallel to the line are also in reinforced concrete and stand out in the form of brackets upon the back wall of the panels.

The Netherlands State Railway Company and the Dutch Railway Company have built with good results arch bridges under the railways up to 20 m. (65 ft. 7 in.) span and others carrying roads over the railways up to 40 m. (131 feet).

In the case of railway bridges, the Melan system with rigid reinforcements has been most largely used and with which the covering can be directly supported for the concreting whereas the arch bridge spanning the railway was erected with two ribbed girders and an independant upper decking. The arches are without joints. The wing walls of relatively great length of the road bridge, and parallel to the line are also made of reinforced concrete, and have reinforcement panels spaced from 2 to 2.50 m. (6 ft. 6 3/4 in. to 8 ft. 2 7/16 in.), which are open at the top.

The Dutch East Indies Railways have built an arch bridge, with 3 hinged joints for 5 lines, of 20 m. (65 ft. 7 in.) span with independant decking, to which are connected at both ends, continuous girders above the two spans each of 7.50 m. (24 ft. 7 in.), which have the form of girder slabs with upper decking. The arches were built separately for each line and connected together by slabs.

Another double track bridge has been built with an arch without hinged joints, of 36.60 m. (120 feet) span. The arches have been formed for each line of 2 ribs upon which rest the supports of the decking and at the centre third the decking itself. The structural details of the two lines are not connected together.

We may also mention a single line bridge with three spans of 13.75 m. + 8.82 m. + 3.75 m. (45 ft. 1 in. + 29 feet + 12 ft. 4 in.) built in the form of a cantilever girder with suspension details of 6.70 m. (22 feet) span in the shore spans. The centre span is made as a panel with two uprights with brackets on the two sides; the abutments also have a panel with two uprights of 3.70 m. (12 ft. 2 in.) width with a bracket on one side.

The openings are masked. For the line, two ribbed girders have been provided.

We should also mention the construction of a double aqueduct of 10.80 m. (35 ft. 5 in.) span each for 11 lines, the details of which are formed by panels with two uprights separated for each channel with incomplete lower pin joints. The different details are of T section with a slab 1 m. (3 ft. 3 3/8 in.) in width; they were built at the site and put in place as soon as sufficiently hard.

In addition the construction of a viaduct of 24 spans each of 9 m. (29 ft. 6 3/8 in), and a viaduct of 11.40 + 13.40 + 13.40 + 11.40 m. (37 ft. 5 in. + 44 feet + 44 feet + 37 ft. 5 in.) spans should also be mentioned. The details were ribbed girders invariably connected to the supports of A form. The first of these viaducts was fitted with expansion joints above the supports and at the centre where the supports are double, whilst the second viaduct is only free to move at the abutments.

The Swedish State Railways have built with good results an arch bridge with non-rigid reinforcement of 90 m. (295 ft.) span.

The Czechoslovakian State Railways have built under the railway arch bridges up to 16 m. (52 ft. 6 in.) span with rigid reinforcements of the Melan system.

On the Yugoslavian State Railways an arch bridge in reinforced concrete carrying the road traffic over the railway has recently been built. The span of the arch is 24 m. (78 ft. 9 in.). The spandrels above the arch as well as the adjoining wing walls are also in reinforced concrete; they are stiffened up by horizontal and vertical ribs and are tied together by the embedded reinforcement. The foot paths are carried on brackets.

For the railway itself an arch bridge of 3 spans of 35 m. (114 ft. 10 in.) opening is under construction and which, owing to the skew of the structure, will be reinforced with round bars.

The use of ordinary concrete for the arches of bridges up to 20 m. (65 ft. 7 in.) span is dealt with in the replies of several Administrations. Among works of this kind exceeding 20 m. (65 ft. 7 in.) span an arched bridge of the Finnish State Railways of 70 m. (229 ft. 8 in.) span may be mentioned, which has only a light reinforcement, and was not designed as a reinforced concrete bridge, and an arch bridge of 6 spans of 45 m. (147 ft. 7 in.) opening which is on the Rumanian State Railways.

In this chapter devoted to bridges we should also mention steel structures which owing to the continuous ballast have been given a reinforced concrete flooring or have been strengthened by the use of reinforced concrete, although on this subject only isolated cases can be quoted.

The Danish State Railways have fitted metal bridges with plain girders and lower flooring with reinforced concrete slabs; at the same time details of the bridge, of I section and the main girders have been embedded in concrete. In order to enable water to run away freely the flooring which has been extended beyond the wall of the abutment is given a slight slope. The expansion device is covered with a copper plate. The results have been satisfactory.

In the same way the Finnish State Railways have used in the case of a bridge which had to carry in a station several tracks full web girders in steel spaced 2.40 m. (7 ft. 11 in.) apart, and built for the ballast a floor in reinforced concrete which entirely covers over the upper face of the structure. In order to facilitate the flow of water the flooring is extended beyond the walls of the abutment and are given a slight slope in this direction. In the longitudinal direction expansion joints have been provided for the two tracks.

The structure in question has been in use too short a time for any statement to be made as to the results obtained.

In a similar manner to that reported by the Finnish State Railways, the Guillaume-Luxembourg Railways have constructed several bridges with the sole difference

that between each track a gap has been provided in the longitudinal direction and that the water runs away through pipes laid along the middle of the bridge, and towards which the slabs of the flooring slope.

The same Administration has also built in reinforced concrete the flooring of several metal bridges with lower decking fitted with transverse and longitudinal girders. The girders have not however been embedded in concrete. The results are satisfactory.

We have also received a few replies with regard to the use of reinforced concrete slabs for the footpaths of railway bridges; they are usually laid on the steel brackets of the footpaths, and promise to give good results.

The Dutch East Indies Railways have reinforced on three viaducts by clothing them with reinforced concrete a total of seven uprights having as much as 15 m. (49 ft. 2 1/2 in.) height which were formed (probably) of cast iron pipes. The four uprights of each pier were given an octagonal section with a longitudinal and spiral reinforcement. In the same way the iron horizontal connections of the old piers were embedded in concrete whilst the reinforcing diagonals in iron between the pipes were removed.

The new uprights were connected at their top by a solid block of concrete upon which the supports of the old details of the steel structure rested. The result of this strengthening of the bridge is satisfactory.

We cannot end this chapter upon reinforced concrete bridges without mentioning the measures which become necessary when heavier train loads are introduced into the working of the railways.

We have only received replies to this question from a small number of Administrations of which one alone from what we have learned has actually carried out the strengthening of a reinforced concrete structure.

This Administration, that of the Dutch East Indies State Railways, has reduced by building a forwardly projecting cutwater the span of a reinforced concrete bridge with ribbed girders the carrying capacity of which was increased thereby. Thanks to the connection of the new brackets with the old structure, a rigid assembly of the panels has been obtained at the same time. Unfortunately the reply does not give any details as to the carrying out of this reinforcement.

As regards the steps required to meet the increase of the liveloads several Administrations consider that this question is not yet one of pressing need, seeing that according, to them, when getting out schemes for reinforced concrete bridges, a high value is not given to the stresses in the steel reinforcement and that moreover the trains used when making the calculations are heavier than the heaviest goods trains that are actually run.

From the replies that we have received, certain Administrations use a very low figure for the tensile stresses in the steel reinforcements; thus for example the Norwegian State Railways fix these stresses at 750 kgr. per cm. (10 667 lb. per sq. inch), and the Bulgarian and Yugoslavian State Railways like the Dutch Railways at 800 kgr. per $cm^2$ (11 378 lb. per sq. inch). In such low values of the stresses any dynamic stress due to the moving load does not come into account. But, as in the case of structures in reinforced concrete there is usually a layer of ballast on the bridge and as the structure itself is relatively heavy the dynamic actions ar notably less than in steel structures of the same span, so that there remains

an ample margin for making full use of the steel reinforcements as a reserve to meet the increase in weight of the moving loads.

The Railway Administrations being often obliged to build and maintain over-bridges, we will make a few brief remarks upon the subject of the action of the combustion gases on structures in concrete, and upon the protective measures adopted.

The Bulgarian State Railways use to protect the concrete and the reinforcement a rough cast layer of cement mortar 2 cm. (3/4 inch) thick and are satisfied with the results.

The Danish State Railways have observed in old structures fissures and flaking of the concrete above the track, but do not use any special protective methods against these defects.

The Egyptian State Railways use black steel plate to protect the concrete and the reinforcement and have not found any harmful action due to the combustion gases upon the concrete of the bridges.

The Finnish State Railways report that in recent years they have been obliged to repair over-bridges but do not state the remedies used.

The Guillaume-Luxembourg Railways use in all cases a wash of mortar to protect the upper faces of the structures and expect good results, but their experience is still not sufficiently long for any statements upon the efficacy of this remedy to be given.

The Netherlands Railways have not so far had any kind of trouble attributable to the action of smoke.

The Dutch East Indies State Railways are of opinion that the gases of combustion are harmless provided that the structure has been properly built.

The Rumanian State Railways use coatings of silicate as a protection against the action of smoke upon the concrete.

The Swedish State Railways use as means of protection against smoke a rough cast sealing up the surface of the structures.

The Czechoslovakian State Railways impose to overcome the harmful action of the combustion gases, the condition that the reinforcement shall be covered with at least 5 cm. (2 inches) of concrete. In addition they use various protective coatings.

The Yugoslavian State Railways have also observed the harmful effect of smoke upon concrete structures over railway lines, and have been obliged to repair old structures. The harmful action of the gases is especially noticed upon reinforcements in flat bars which have only been covered with 1 to 2 cm. (3/8 to 3/4 inch) of concrete. Up to the present no protective measures have been taken but as a test the application of wooden protecting panels on structures especially exposed to the action of smoke is under consideration; this method has given good results on metal structures.

As can be seen from the replies quoted above the construction of bridges in reinforced concrete is already greatly extended on the railways. In particular many examples of small under bridges show that this method of construction is frequently selected because the ballast can be continued over it without interruption, which represents a considerable advantage as regards the formation of the line.

In certain isolated cases the rails, and in some cases the sleepers have been laid directly upon the concrete structure; this is a practice that should be absolutely

avoided owing to the disadvantages which result from it. Where owing to the small depth of the structure the use of a layer of ballast less than 25 cm. (10 inches) deep under the sleeper is not possible, in place of reinforced concrete, some other method of construction should be selected. In order to properly distribute the pressures to lessen the dynamic action and for maintenance work the depth of 25 cm. (10 inches) below the sleeper can be considered as sufficient. This dimension may also include a protecting layer over the structure.

If we ignore the structures in which the main girders in order to delimit the bed of ballast extend above the ballast, lower deck bridges or suspension bridges do not appear to be favoured by the Railway Companies; in one case definitely bad results have been reported. In any case when it is a question of structures of this kind special attention should be given, when getting out the scheme, to the rigid connection between the main girder and the cross girders which especially is subjected to high stress

An examination of the methods of construction of the large reinforced concrete bridges shows that the most varied methods have been employed which shows that the method of building in reinforced concrete is usable and practicable for the most diverse circumstances, and adapts itself easily to local conditions.

As can be seen from the technical literature there are also in Germany besides the many railway top road bridges, very few trough bridges. Amongst these latter may be mentioned :

1. The railway bridge over the Werra, at Heringen, of 53 m. (174 feet) span. This is an arched beam bridge with double ribs without pin joint, with the floor in reinforced concrete suspended by steel links and divided at two points to allow for expansion;

2. The railway bridge over the Sarre near Völklingen of 60 m. (197 feet) span. This is an arched beam bridge with double ribs without joints with the floor in reinforced concrete held by links embedded in concrete. The floor is fitted at the centre with an open joint. On both sides of the main span this bridge is joined to reinforced concrete viaducts which are built up of ribbed girders with upper flooring. On one side a small bridge arch of 28 m. (92 feet) span with upper floor is also built into the viaduct.

Metal bridges with the floor in reinforced concrete have only been built in exceptional cases. Although the results obtained with such bridges have been good so far it must not be forgotten that the monolithic character of the system no longer exists in such cases. The deflections of steel bridges under rolling loads are greater than those of reinforced concrete bridges and obviously these greater deflections also act upon the floor which influence possibly will only be seen after some time by fissures in the concrete slabs. In any case this method cannot be approved if as in one case the floor has been built without joint for the two lines.

It is absolutely necessary that there should be a cut between the lines to prevent on one hand mutual reactions when one line only is under load, and on the other the formation of fissures in the concrete.

Even in the case of bridges built up of rails or I sections embedded in concrete or with reinforced ribbed girders the deflection of which is relatively small it is to be recommended according to the experience now available the structures be

built without a separating joint for two lines at most.

As regards the economic superiority of bridges with ribbed girders and upper floor it is possible that on the standard gauge main lines with loads of 20 tons per locomotive axle now usual that it reaches its limit for spans of 15 m. (49 ft. 2 1/2 in.). On narrow gauge lines this limit increases to about 20 m. (65 ft. 7 in.). Undoubtedly from the economic point of view not only should one consider the span of the structure but that an important role is played by other factors of a local nature which cannot be considered separately in the general scheme but should be studied individually in each particular case.

For the bearings of the slabs and the rib girders of aqueducts of up to 5 m. (16 ft. 5 in.) span it is quite sufficient to use lead sheets or two or three thicknessess of hard bituminous felt; but when it is a question of larger spans of from 5 to 15 m. (16 ft. 5 in. to 49 ft. 2 1/2 in.) it is necessary to use reversible slides. For still larger bridges is is desirable to use the same type of bearing as for metal bridges in order to obtain a proper action at the bearings or at the joints.

### B. — Station buildings and platform shelters.

Few of the Railway Administrations deal in their replies with the construction of station buildings and shelters.

The Netherlands State Railways and the Dutch Railways mention two cases of large umbrella type shelters connected at several places with transverse buildings in reinforced concrete. Expansion joints are provided at distances of 16 to 27 m. (52 ft. 6 in. to 88 ft. 7 in.), that is to say every two or three columns and the corresponding column is then doubled. The dividing joint is carried down to the foundation. The columns are connected by a strong longitudinal girder to which the cross girders are connected at distances of 3.50 to 4 m. (11 ft. 6 in. to 13 ft. 1 1/2 in.).

The Dutch East Indies State Railways report that they have at the present time umbrella type shelters in reinforced concrete under construction, but give no detailed information on the subject.

The Rumanian State Railways reply that some of their stations have reinforced concrete shelters but give no details of the method of construction, nor on the results obtained.

The Yugoslavian State Railways have only a few stations with reinforced concrete shelters. The most important of these buildings is a shelter which takes its bearing on one side on the main wall of the station building and on the other side near the track upon columns spaced at 8.70 m. (28 ft.-6 1/2 in.) centres. The columns are connected by a longitudinal girder into which are built the transverse girders. Expansion joints are provided above every third column that is to say at distances of about 26 m. (85 ft. 3 in.).

During last winter which was extremely severe it was found that this spacing between the expansion joints was too great.

The result of all the replies that we have received is that no one has taken any kind of action against the harmful effect of combustion gases upon roofs in reinforced concrete, and that can be understood seeing that it is only a question of shelters above the platform and not of shut in buildings over the running lines.

As regards the distance apart at which expansion joints should be provided the

practice differs widely from one Administration to another; it varies from 15 to 50 m. (42 ft. 2 1/2 in. to 164 feet). Bearing upon the experience of last winter, the Yugoslavian State Railways suggest a spacing of about 15 m. (42 ft. 2 1/2 in.).

In a general manner the shelters in reinforced concrete have given good results; their principal advantage is that the costs of upkeep are extremely low.

In building these shelters it is necessary to see that a proper covering of the surfaces is obtained and that water runs away freely, especially in the longitudinal sense, and to design with care the arrangement of expansion joints the spacing of which corresponding to the local variations of temperature should not be excessive if one wishes to avoid harmful effects due to such variations.

### C. — Locomotive depots.

Amongst railway buildings, reinforced concrete is most widely used for locomotive sheds.

The Alsace and Lorraine Railways report that the Guillaume-Luxembourg Railways possess several round sheds in which, not only the columns and the roof, but also the outer wall and consequently the whole building have been built in reinforced concrete. This Administration gives as its reason for adopting the monolithic form of construction that when the ground is bad or when there is reason to expect disturbances thereto through the traversers or the cranes in the neighbourhood, this method of construction is better than that which consists of columns in reinforced concrete filled in between with brick work owing to the cohesion and homogenity of all the parts.

The smoke of the locomotives is evacuated locally, that is to say by smoke jacks and chimneys placed above each line.

As regards the question of knowing if when evacuating the smoke centrally by reinforced concrete jacks, the warm gases from the locomotives exercise a harmful action upon the latter this Administration is of the opinion that with a sound reinforced concrete structure when the reinforcement is sufficiently deeply embedded the smoke jacks can quite well stand up against the action of the smoke. It has not however any experimental results to support this opinion.

The Norwegian State Railways report that they have built two locomotive sheds in reinforced concrete and these have given good results. They do not send however any other details.

The Netherlands State Railways and the Dutch Railways report that they have a locomotive round shed the foundation and columns of which are in reinforced concrete. The outer walls are however in brick these Administrations considering that the reinforced concrete construction was not suitable for this purpose owing to possible damage caused by the locomotives and in view of a possible extension of the buildings. Smoke is evacuated locally and these Administrations consider that the action of the smoke upon the jack in reinforced concrete is not serious, although they have not been satisfied with the results obtained with some smoke jacks built in reinforced concrete.

From information supplied by the Rumanian State Railways this System possesses already several roundhouses as well as another under construction with the colums and roof in reinforced concrete.

The outer walls are in brick; it is thought that it is not practicable to build them in reinforced concrete. The sheds

are designed for the local evacuation of the smoke; but the jacks are in reinforced concrete 5 cm. (2 inches) thick protected against the attack of the combustion gases by a coat of « Inertol ». The administration has not given any information upon the action of the combustion gases upon the jack owing to the short time that these sheds have been in service.

The Swedish State Railways possess on their system round houses and rectangular sheds in which the columns and roofs only or the columns alone are in reinforced concrete. The outside walls are always of some other material. The smoke is sometimes evacuated locally, sometimes centrally. Although with the central system a destructive action of the smoke upon the concrete has been observed up to the present no protective steps have been taken against it.

The Yugoslavian State Railways have one round house built entirely in reinforced concrete and another in which reinforced concrete has only been used for the columns and the roof. The choice of reinforced concrete for the outside walls of the first was imposed by economic reasons, as in this case concrete costs less than brick work. The smoke is evacuated in these sheds locally. In a general manner the results have been satisfactory.

To sum up it can be said that the numerous applications confirm that reinforced concrete has shown itself to be satisfactory for use in the construction of locomotive sheds. The replies to the questions as to whether it is practicable to build the outer walls in reinforced concrete depends upon local conditions, such as bad ground, disturbances due to other services, and thereby requiring a monolithic construction, etc.... It is not possible to lay down any general rule on this subject.

From the replies received it appears that most of the Administrations prefer to get rid of the smoke locally. When the smoke is evacuated centrally by concrete smoke jacks opinions upon the extent of the destructive action of the smoke upon the concrete are divided. This action has however been noted by several of the Administrations who have fitted their sheds with central jacks in concrete. Seeing that in the presence of water the sulphur from the coal burnt in a locomotive is transformed into sulphurous acid and that this exercises a destructive action on concrete it is certain that the more or less large per cent of sulphur in the coal has an influence upon the more or less good or bad results that the Administrations have obtained with smoke jacks in concrete, and this is no doubt where the reason can be found for the difference of the opinions given.

In any case it is desirable to maintain in good state the smoke jacks and that these latter should be given some protecting coat against the action of the combustion gases.

Owing to the great differences of temperature to which the jacks are exposed, it is necessary to allow for changes in length and to see that by a suitable arrangement of the jacks when building the locomotive sheds that their free movement is not hindered, so that harmful stresses shall not be set up in the different parts of the structure.

### D. — Chimneys.

On the subject of reinforced concrete chimneys we have received replies from the following three Administrations only: Danish State Railways, Netherlands State Railway Company and the Dutch Rail-

way Company, and the Yugoslavian State Railways.

From these replies the Railway Administrations of the Netherlands are the only ones who have obtained good results with reinforced concrete chimneys, whereas the replies from the other two Administrations are not favourable and stress the fact that in all cases chimneys of this type must up to a certain height be lined with ordinary brick or fire brick if the harmful action of the combustion gases upon the reinforced concrete of the chimneys is to be entirely prevented. Unfortunaley the reply from the Railway Administrations of the Netherlands do not state if the reinforced concrete chimney in question is lined inside and up to what height, or not.

However this may be it is not possible to draw any conclusions from the few replies received upon the use of reinforced concrete for chimneys. We shall therefore be satisfied to repeat that in constructions of this kind it is necessary to provide an interior lining up to sufficient height in order to eliminate any harmful action from the hot combustion gases upon the concrete. Here again the more or less high content in sulphur of the coal burnt undoubtedly plays its part, but no accurate experiments have been made upon this matter.

### E. — Ash pits.

Thanks to the simplicity of construction ordinary concrete is used by almost all the Railways for the ash pits.

In addition several Administrations state that reinforced concrete is used for this purpose.

The Danish State Railways report that they have built ash pits in reinforced concrete when the ground was not particularly good or when it would have been necessary to use piles. The walls in such cases act as continuous carrying girders. It is only under such conditions that the Administrations consider the use of reinforced concrete as economical.

In one case the ash pit is carried on reinforced concrete piles 25 cm. (10 inches) in diameter driven in at distances of 2.30 m. (7 ft. 6 1/2 in.).

The thickness of the walls of the pits is 35 cm. (14 inches) and that of the reinforced concrete bottom slab, 13 cm. (5 1/8 inch.).

For pits much used a destructive action of the ashes upon the walls and floor has been noticed both with ordinary and reinforced concrete. But the investigations into the provision of means for overcoming this action have not yet been completed and for the time being the ashes are being allowed to fall directly into steel tubs.

The Finnish State Railways also mention ash pits in reinforced concrete; they do not consider them as economical except when owing to bad ground an artificial foundation is required.

In the case of one of the pits built by this Administration circular piles 1.50 m. (4 ft. 11 5/16 in.) in diameter spaced at 6 m. (19 ft. 8 1/4 in.) centres placed under the two walls and on which the trough shaped pit rests, have been used.

The walls act as continuous girders, and as the total width of the pit and of the masonry exceeds by 25 cm. (10 inches) on each side, the diameter of the piles, solid bearings built up by rails embedded in concrete arranged transversely have been built on the top of the piles.

With regard to the destruction of the concrete by gases this Administration has not yet been able to give any information the pit in question having been in service too short a time. Up to the

present no protective measures have been taken to prevent this action.

The Prince Henry Railways and Mines report that the ashes attack the concrete of the ash pits very seriously and that repairs are required every two to three years. As a method of protection they use with success rails placed close togethe along the walls.

The Guillaume-Luxembourg Railways reply that reinforced concrete ash pits have only been built in the mining districts or where the ground is bad. As reinforcement rails are used. This Administration has noticed also the destructive action of hot ashes and of alkaline waters upon both ordinary and reinforced concrete; it has lined with good effect the walls with special bricks (silica-firebricks).

The Norwegian State Railways have also built an ash pit in reinforced concrete when the foundations were not good. Up to date this Administration has not noticed any destructive action due to hot ashes or to alkaline waters upon the concrete.

The replies from the Netherlands State and the Dutch Railway Companies show that these Administrations have not built ash pits in reinforced concrete except under certain circmustances when the ground was bad.

In one case under each of the walls solid piles 1.25 m. (4 ft. 1 1/4 in.) diameter spaced 3.60 m. (11 ft. 9 3/4 in.) apart were driven and were connected by a reinforced concrete slab upon which rested the pit built up of ordinary bricks. This method of construction was selected after having found by experience that hot ashes and alkaline waters strongly affect the concrete and that it was absolutely necessary to protect the latter by a brick lining at least.

In a depot where the ashes were collected this protection was obtained by using tiles.

The Rumanian State Railways do not consider the use of reinforced concrete for ash pits as economical except in the case where it is necessary to use piles. As this Administration also considers that alkaline waters and hot ashes are destructive to concrete they line their concrete ash pits with an interior lining of stone, or bricks.

The Swedish State Railways have built, when the ground is bad, ash pits in reinforced concrete built in the form of an open container. The ashes falling directly into portable tubs in sheet iron this Administration has not found any destructive action upon the concrete and has not used any protection at all.

The Oxelösund-Flen-Västmansland and the Västergotland-Göteborg Railways who have so far only built ash pits in ordinary concrete have also found a destructive and progressive action of the hot ashes and alkaline waters upon the concrete but up to date have not used protective measures.

The Yugoslavian State Railways have also built when the ground was bad ash pits in reinforced concrete. In order to protect them against the destructive action of hot cinders and alkaline waters they recommend the use of linings on the walls and on the floor.

To sum up, it may be said that all the Administrations build ash pits in concrete for economic reasons owing to the rapidity with which the work can be done and owing to the monolithic structure obtained.

On the other hand ash pits in reinforced concrete are only considered more economical than those built with other materials when the ground is bad or where unequal settlings are to be feared such as in the colliery districts.

As all the Administrations call atten-

tion to the destructive action of the hot ashes and of the alkaline waters on the concrete if the ashes are not collected in special recipients the lining of the pits in thin brick, ordinary brick, etc., is recommended.

#### F. — Turntable pit walls.

As in the case of ash pits nearly all the Administrations use concrete for the turntable pit walls and for the central pier of the tables.

With regard to the use of reinforced concrete for this purpose we have received replies from several Administrations.

The Danish State Railways have constructed for a 12.80-m. (42 feet) turntable the wall in reinforced concrete because, owing to bad ground, piles have to be used. The piles in reinforced concrete have a square section 25 cm. (10 inches) side and were driven at distances apart of about 1.50 m. (4 ft. 11 5/16 in.). Under the foundation of the pivot, 6 piles were used. The pivot is connected to the wall by 8 reinforced concrete girders to which are connected the reinforced concrete slabs of the pit floor. The rails of the runway are carried on hard wood sleepers bolted to the concrete. The results obtained are satisfactory.

The Egyptian State Railways have built upon an ordinary foundation the boundary wall of a turntable in reinforced concrete, and are satisfied with the result. They have not given any particulars of the method of construction nor of the reason why this method of construction was chosen.

The Netherlands State and the Dutch Railway Companies have already fitted for economic reasons several turntables with the walls in reinforced concrete and are very satisfied with the result. In two cases the masonry rests upon wood piles; in one case it is carried on a slab of concrete reinforced in cross form, of 30-cm. (12-inch) thickness which is carried under the whole of the turntable. The diameter of the different turntables is 20 and 18 m. (65 ft. 7 in. and 59 ft. 5/8 in.).

In one of the turntables carried on piles the walls are carried down 6 m. (19 ft. 8 1/4 in.) below the level of the top of the sleepers. In this case the wall is divided up into pillars 70 cm. × 1 m. (2 ft. 3 1/2 in. × 3 ft. 3 3/8 in.), spaced 3 m. (9 ft. 10 1/8 in.) apart approximately which rest on a lower ring in reinforced concrete 1.50 m. (4 ft. 11 5/16 in.) wide and 1.15 m. (3 ft. 9 3/8 in.) high, and are connected on their upper surface by a ring 1.50 m. wide and 1 m. (3 ft. 3 3/8 in.) high which serves at the same time to carry the rails. The lower ring is connected to the centre pillar by four reinforced concrete girders.

In the case of the other turntable carried on piles the height of the circular pit wall was low; this wall forms a ring in reinforced concrete upon which were carried the rails. Here again the pit wall was connected to the centre pier by four reinforced concrete girders.

In the event of crane rails with a large base being used for the runway they were fastened down by means of rag-bolts or if ordinary Vignoles rails were used by means of special bearing plates the plates and the rails being fastened down separately.

The Dutch East Indies State Railways mention two buildings in reinforced concrete. The presence of underground water and bad ground were the causes of this method of construction being selected and the results have been very satisfactory.

The diameter of the turntables in question is 20 m. (65 ft. 7 in.).

In one case in which the underground water was near the ground level the main central pile about 6 m. (19 ft. 8 1/4 in.) in diameter, is connected to the pit wall which is made of concrete and is 2 m. (6 ft. 6 3/4 in.) thick by a flooring in reinforced concrete which is laid without break from the pivot and is raised at the pit wall up to the water level. Between the pivots and the wall 16 ribs reinforce the flooring. This flooring is provided with an annular reinforcement. About the central pier and the pit wall the ribs are connected by rings in reinforced concrete which are solidly anchored to the masonry foundation of the pivot and of the pit wall so as to support the thrust of the underground water. The pit is kept clear of water by pumps.

In the second case a flooring in concrete 70 cm. (2 ft. 3 1/2 in.) thick in the middle and 35 cm. (1 ft. 1 3/4 in.) at the edges with an upper and lower annular and radial reinforcement extends over the whole of the turntable and carries directly the central pier and the rails. The latter which are ordinary Vignoles rails are fastened down with special bearing plates secured in position by rag-bolts.

The Swedish State Railways do not use pit walls in reinforced concrete for turntables except in cases in which it is necessary to build on piles or when owing to bad ground the weight has to be distributed over a greater surface.

In the case of bad ground, the Yugoslavian State Railways have also used for a number of turnables a pit wall in reinforced concrete carried on piles.

As can be seen generally from the replies quoted above, the use of reinforced concrete constructions for the foundations of turntables is only justified in certain circumstances. It is used in most cases in which it is necessary to build upon piles and when it is necessary to tie together the whole details of the struction in a monolithic arrangement or to save material. Another reason is found when the water level is high; in this case it is essential that the pit of the turntable should be properly lined out and that in order to resist the thrust from the underground water it should be thoroughly anchored into place with heavy foundations. The reinforced concrete however should only be used for the lining and not for the body of the foundation itself, as the latter should be of ample size as they act as supports and can in consequence be usefully made of ordinary concrete.

### G. — Water tanks.

With regard to the use of reinforced concrete for the construction of water tanks, replies have been received from several Administrations.

The Danish State Railways have obtained good results with water tanks in reinforced concrete; see in this connection the preliminary Papers of the Rome Session in 1922, Question IV, Report 7, *Bulletin of the Railway Congress,* January 1922, pp. 25 et seq.

The Guillaume-Luxembourg Railways have built water tanks in cylindrical form built on reinforced concrete columns and are very satisfied with the results.

The Netherlands State and the Dutch Railway Companies have also a large number of water tanks of reinforced concrete of different forms.

As regards water columns the walls of the tanks are usually cylindrical; in one case they are octogonal in form and in most cases the tank is divided by a cylindrical division into two holders.

The support is sometimes in solid brickwork carried on a foundation in reinforced concrete intended to distribute the load, and in other cases it is carried on pillars of reinforced concrete which are also connected to a foundation distributing the load.

As a general rule no special protecting lining is used on the inside cases of the reservoirs.

The Railways are entirely satisfied with these water tanks.

In addition to the water columns, rectangular reservoirs sunk in the ground have been built entirely of reinforced concrete.

In one case the large sides of the rectangle are reinforced by plain ribbed panels which start from the bottom and are carried above the cover. In another case in which the rectangular reservoir is subdivided by three transversal solid partitions it was found possible to avoid having to strengthen the longitudinal faces in reinforced concrete.

The Dutch East Indies State Railways report the construction of a large water column with cylindrical reservoirs on two stages entirely built of reinforced concrete as were also the columns carrying the tanks.

The whole structure rests upon a foundation distributing the load.

The upper reservoir, which contains 500 m$^3$ (17 568 cubic feet), is divided by a cylindrical wall into two holders. The lower reservoir contains 125 m$^3$ (4 392 cubic feet). Below the reservoirs are placed at different heights mixers and filters and an intermediate reservoir of clean water, the whole in reinforced concrete.

A further water tank containing 150 m$^3$ (5 297 cubic feet) also cylindrical in form is carried, at it is not more than 3 m. (9 ft. 10 1/8 in.) above the ground level, upon a cylindrical wall in reinforced concrete which is widened at the base to act as a kind of footing.

The Rumanian State Railways report the construction of water colums with cylindrical reservoirs which have given satisfaction.

The Swedish State Railways have also built water reservoirs in reinforced concrete. In certain cases these are the reservoirs themselves only, in other cases the supports alone have been built of this material.

The Yugoslavian State Railways have a number of water columns in reinforced concrete. These reservoirs are cylindrical and are carried in some cases on reinforced concrete columns, in others on brickwork. Occasionally the support with the columns and an upper ring alone are in reinforced concrete, whereas the reservoirs themselves of steel plate spherical in form are carried through rivetted brackets upon the upper ring. The results are good.

After replies received good results have been obtained with reservoirs built in reinforced concrete.

An essential condition is that, in order to avoid fissures occurring in the reservoirs, the tensile stress supported by the concrete must not reach too high values; the result is that the use of metal reinforcements in the walls of the reservoir up to the allowable limit of stresses is only possible in rare instances. The greatest importance must be given to the water tighteness of the concrete and in order to get this the inside surface of the reservoirs must be given a rough coating of cement mortar. It is recommended that special coatings and measures to make the cement impermeable be used.

Thanks to its becoming unnecessary to

repaint as with steel reservoirs, reinforced concrete reservoirs have the advantage over the latter of being cheaper to maintain.

H. — Tunnels.

The following information is taken from the replies received.

The Bulgarian State Railways use with good results ordinary concrete when renewing the lining of existing tunnels as well as for lining new ones.

The Danish State Railways have used concrete without lining in two tunnels. The problem of protecting the concrete from the attack of smoke has been very thoroughly investigated, but up to the present no measure of lasting success has been discovered.

The Guillaume-Luxembourg Railways report that on this line only ordinary concrete has been used. No special means are taken to protect the concrete against the action of the combustion gases. In order to keep water from penetrating into the masonry of the tunnel various products are used but especially that known as « Mammouth ».

The Norwegian State Railways have recently built a double track tunnel entirely in reinforced concrete. The construction was not carried out in the ordinary way as in a tunnel, but in an open cut, so that the tunnel is of rectangular section and has the form of a plain panel with intermediate supports.

This latter is provided with openings like windows. This tunnel has been is use too short a time for any information to be given as to results obtained in practice; it is not stated if any protective design is taken against smoke.

The Swedish State Railways have fitted their tunnels running through broken rock with linings in reinforced concrete. As a method of protection against the combustion gases they use coatings of « Inertol » or a layer of cement applied with the cement gun.

The Czechoslovakian State Railways have reinforced in one case an existing tunnel with reinforced concrete, by using as reinforcement twisted rails. The results have been satisfactory.

In another case as a test a segment of tunnel of a railway with a single track has been built in concrete reinforced with rails and round rods. In this way it has been possible to reduce the excavation work and in consequence the first costs.

The Yugoslavian State Railways have used ordinary concrete for the construction of new tunnels as well as for the renewal of the masonry of existing tunnels. In this case the best results have been obtained by using concrete blocks which have to be made in special moulds at least 6 weeks before use.

In one case an existing tunnel has been lengthened 30 m. (98 feet) by reinforced concrete owing to the sides of the approach cutting having slipped and as the consolidation of this cutting by means of retaining walls would not have given complete safety. The reinforcement of the Melan system carried the shuttering so that scaffolding was not necessary, such scaffolding being objectionable from the train working point of view. The result obtained was good. The cost of maintenance was nil. Up to the present no protection devices have been used against the destructive action of the combustion gases.

The use of reinforced concrete in new tunnels and in maintenance work on existing tunnels have not taken place so far except in a very few cases but in such cases it has given good results. On the other hand ordinary concrete has been used not only for the construction of new

tunnels but also in the case of renewal of defective linings of existing tunnels as well as in the form of concrete blocks.

Some Administrations point out the need for protection against attack by smoke.

**I. — Sustaining walls, linings and platform walls.**

From the replies received from the different Administrations it appears that walls have been built in reinforced concrete only in rare instances up to the present.

The Danish State Railways have only used reinforced concrete for sustaining walls of the ⊾ profile in a few cases in which special circumstances make it necessary although the results obtained so far have been good. Expansion joints are provided every 20 to 25 m. (35 ft. 7 in. to 82 feet).

The Egyptian State Railways have successfully used sustaining walls of reinforced concrete. The expansion joints are placed every 25 to 30 m. (82 to 98 feet).

The Netherlands State and the Dutch Railway Companies have built sustaining walls of reinforced concrete about 280 m. (918 feet) long of ⊾ profile, with up to 6.50 m. (21 ft. 4 in.) free height. The ribs are spaced about 2 m. (6 ft. 6 3/4 in.), the front wall has a slope of 1 in 16.

In several cases platform walls in goods sheds have also been built in reinforced concrete. The spacing of the ribs varies from 1.50 to 2.50 m. (4 ft. 11 5/16 in. to 8 ft. 2 7/16 in.). To protect the coping against damage the walls are often finished off in stone.

It is recommended that expansion joints should be arranged 15 to 20 m. (49 ft. 2 1/2 in. to 65 ft. 7 in.) apart.

As can be seen, reinforced concrete is not yet often used by the Railway Administrations for sustaining and other walls. Ii is necessary that there should be particular local circumstances which would justify from the economical point of view the construction of a sustaining wall in reinforced concrete before this would be done.

Undoubtedly walls of this kind should be tight and well drained, otherwise frost owing to the thinness of the walls will exercise a harmful action as regards their life.

Reinforced concrete has been used upon rather a large scale for the walls of station platforms and in this case it has given good results.

On the other hand ordinary concrete has found on all Railways many applications on a wide scale for sustaining walls, for linings, and for platform walls.

When these walls are more than a certain length care must be taken that they are divided by suitably spaced expansion joints otherwise cracks will result which do not ordinarily affect the life of the wall but detract from its good appearance.

As regards the spacing of expansion joints the Administrations give a figure of 10 to 15 m. (32 ft. 9 3/4 to 49 ft. 2 1/2 in.), It is however advisable to keep to the lower value and only to use the higher in exceptional cases and when the conditions are particularly favourable.

**J. — Posts carrying electric transmission lines.**

As regards the use of reinforced concrete for posts carrying transmission and distribution lines we have only received a brief reply from the Czecho-slovakian State Railways which use posts of this kind for lighting conductors but

give no details upon the technical and economical results obtained.

It can therefore be said that upon the Railways with which this report deals reinforced concrete has not yet for economic and pratical reasons taken the place of wood for posts carrying transmission lines.

### K. — Other constructions in reinforced concrete on railways.

Upon the subject of other buildings in reinforced concrete for railways we have received several replies.

The Guillaume-Luxembourg Railways use sucessfully portable houses in reinforced concrete of which the roof and walls can after being taken apart be readily moved and rebuilt elsewhere. The drawback of these cottages is that their insulation is defective as regards heat transmission.

The same Administration has built coal bunkers in reinforced concrete built up with ribbed slabs and pillars, but has not been able to give information upon the results owing to them having been too recently put into use.

The Netherlands State and the Dutch Railway Companies have built reinforced concrete plants for unloading coal and are very satisfied with the results.

Furthermore, they have built signal boxes of one or two stories the substructure (columns walls and brackets) being in reinforced concrete, while the cabin properly said which carries the centralised operating gear and signalsman, is in wood. The results obtained are good.

The Oxelösund-Flen-Västmanland Railway has built with a view to unloading minerals, for a line of 700 mm. (2 ft. 3 1/2 in.), a reinforced concrete wall of 1.50 and 1.70 m. (4 ft. 11 5/16 in. and 5 ft. 6 7/8 in.) thick serving as a railway platform; as the ground was bad a certain increase in width was given to it on the two sides therebey forming brackets. The rails which are crane runway with large base are carried on the wall though metal bearing plates. The results of this installation are very satisfactory.

The same Administration has also used reinforced concrete for building the columns of its goods sheds whereas the walls between the columns were made of 7 1/2 cm. (3 inches) thick brick of the Frazzi type. The maintenance costs being low this construction has been also satisfactory.

The Yugoslavian State Railways have built wagon repair shops, part being buildings with columns having a reinforced concrete roof whereas the boundary walls in the part not glazed are built up of brick and the others of simple roof construction with intermediate supports upon ordinary boundary walls in brick. These buildings which cost little to maintain, give every satisfaction.

### L. — Reinforced concrete fencing and other details.

The replies of the different Administrations frequently mention the use of reinforced concrete for fencing as for the manufacture of various details such as posts, slabs, pipes, conduits etc., which are easy to carry and to put in place where needed.

There is no doubt that parts of this kind such as the posts carrying overhead lines, slabs, etc., when they are not exposed to violent shocks or when the pipes and conduits are not attacked chemically have many economic advantages as regards their life, as regards the possibility of using them a number of times at dif-

ferent stations and by their low cost; consequently they are widely used. It must be added that on the railways there is always plenty of old material such as pieces of rails, wire, smoke tubes, etc., which can be used advantageously for reinforcing the concrete details mentioned above. As regards fencing care must be taken that it is made as much as possible of posts and slabs or other pieces or that expansion joints are provided every 10 m. (32 ft. 9 3/4 in.) at most, as otherwise owing to the thinness of work of this kind, fisures will unavoidably appear.

### M. — Summary.

The possibility of using reinforced concrete for the different constructions on railways does not lend itself to general and detailed conclusions; we would return on this subject to the summaries which are given at the ends of the chapters devoted to the various kinds of constructions. It has however been shown in a general manner that concrete and reinforced concrete, thanks especially to their low cost of maintenance, have found with good results their largest use on railways for constructions of the most varied types. The complete success depends upon good and accurate carrying out of the work and it is essential that the work should be very, carefully and intelligently supervised. This should be especially so in the case of bridges and other structures over which trains run, as these works have not only to carry the dead load but also dynamic stresses difficult to calculate.

From the point of view of the necessary economy which should govern the building of the structures, today the addition of a quantity or of a determined weight of cement to a unit volume of agglomerate or of concrete as was done formerly without taking into account the more or less good or bad qualities of the cement utilised is no longer required provided it meets generally the conditions laid down in the specifications.

What should serve as criterion when carrying out constructional work is the quality of the concrete that can be got with a determined quantity of cement. Recently the cement industry has made considerable progress. Cements of a compression strength of 400 to 500 kgr. per cm² (5 680 to 7 100 lb. per sq. inch) which ten or twenty years ago passed as a very good product, can no longer be qualified except as averagely good seeing that compression strengths of over 700 kgr. per cm² (9 940 lb. per sq. inch) at the end of 28 days setting are not unusual.

Consequently when it is a question of constructions in which for economic and technical reasons great compression strength cannot be fully used, the quantity of cement per unit volume can be diminished. But in this case for that the limit should be observed carefully a thorough checking of all the materials used and of the finished concrete produced with these materials should be carried out and a close inspection should be made during construction.

The development of excellent qualities of steel and their use in reinforced concrete work, steels which do not always give good economic results unless at the same time superior quality cements are used, have acted as a further stimulant to the extended application of reinforced concrete on the railways.

In this way it becomes possible to meet the harder conditions resulting from the growth of the rolling loads, as for example in the case of bridges and to in-

crease in this way the carrying capacity of these structures.

In the form of cement obtained from burning clay and cements which rapidly attain great strength, a material has been put upon the market which makes it possible to put into service a few days after completion structures in which these cements are used. In many cases when it is a question of the construction of bridges or ash-pits, repairs to tunnels, etc., this property can be of great importance as for operating reasons it is only necessary to take possession of the line for a very short time for carrying out the work.

Another advantage of ordinary concrete and of reinforced concrete is that *a monolithic construction is obtained*. It is used especially when the structure also supports dynamic action and where it is necessary to make provision for the settlement of the ground. By introducing steel reinforcements in structural parts not generally called upon to absorb any but compression stresses such as arches, roofs, supports, bridge abutments, etc., they can be given a closer cohesion and their capacity of resistance to shocks, unequal settlements of ground, etc., can be greatly increased.

It may be that it is in part due to the advantages of the monolithic system that the use of concrete has become so widespread for the construction of bridge abutments and the foundations of walls as well as structures in mining districts where more or less importants settlements are always to be feared.

Another advantage of reinforced concrete is also that it is not affected by fire and this makes its use a practical feature in the building of warehouses, workshops and other buildings.

When it is a question of building structures in reinforced concrete for railway purposes there is one essential point which must not be neglected. The railways are comparable with living organisms which must adapt themselves to the changes of an economic and commercial kind by extending their installations by reconstructions, etc. Now the demolition of reinforced or ordinary concrete structures is not only more difficult than those of other materials, but gives material without value and difficult to dispose of. It is therefore necessary before deciding to build a structure in ordinary concrete or in reinforced concrete upon or near to railways to examine the whole of the possibilities of re-arranging or extending the station, so that the structure has not to give place to others in the near future.

Probably in this fact is to be found the reason why shelters over platforms which have given good results as regards maintenance costs are still used so rarely.

In addition it is as well to consider that with concrete construction ultimate alterations of the structures as well as the application after completion of conduits, transmission, etc. can only be done with difficulty and at great cost, and are sometimes even impossible when an excessive settlement of the parts results or when a too great load is carried and it is not possible to reinforce the structional parts. When it is a question of work of this kind it is therefore necessary to prepare the drawings of the installation in good time, taking into account future requirements.

As regards railway bridges in reinforced concrete it is also necessary to take precautions in order to meet future requirements by allowing greater loads in the calculation and by lowering the stress limits of the materials, although in view of the greater dead weight of bridges in

reinforced concrete an increase in the rolling load is less felt than in the case of steel bridges.

The lowering of the maximum allowable stress should be greater on the steel the strength of which does not vary, provided there are no harmful stresses. On the other hand with time, the strength of concrete increases and for this latter it is possible to maintain the reduction of the maximum admissible stress within very close limits, even if not to entirely suppress it.

Whilst the replacement of metal bridges by stronger bridges can be carried out in a number of hours without upsetting the traffic, this operation has only taken place so far on reinforced concrete structures of small size or upon flooring strengthened with rails or I girders. The great structures in reinforced concrete have to be built in position. When consequently in the case of single line railways or for those with double tracks and very heavy traffic the provisional deviation of the line in line with the yard or remaking below it in order to replace a metal bridge by a reinforced concrete structure, cannot be carried out for technical and economic reasons, it often becomes necessary that the scheme for a reinforced concrete structure, while generally less costly and more practicable, gives place to renewal by a steel bridge because the working of the railway does not allow the movements of the trains to be interrupted too long. It is probable that the use in constructions of this kind of cement obtained by fusing clay or of cement which rapidly becomes of high strength will contribute to making structures in concrete more general on the railways.

As regards the action of locomotive smoke upon constructions such as tunnels, overbridges, smoke conduits and chimneys, it can be said in a general way that in the absence of humidity and provided a properly finished concrete with a high and smooth surface preventing the smoke from penetrating into the mass of the concrete is used, no harmful action of the smoke is noticed ordinarily.

However it is necessary in all cases to place the bars of iron or steel sufficiently far from the surface so that, should the surface of the concrete become destroyed which might occur in damp places, the reinforcement will not be attacked by rust.

It should also be mentioned here that at one time the South Austrian Railway carried out chemical analyses of several samples of concrete taken down to a depth of 1 to 3 cm. (3/8 to 1 3/16 inch) upon Monier roofs in service for over 13 years above a line with very heavy traffic.

These test pieces were taken at points where the smoke had exercised a considerable action. It was found that the layer of soot was confined to the surface, that the metal reinforcements and even the thin binding wires were intact, that tests with these wires did not reveal any molecular transformation of the iron, that the concrete had not been attacked chemically by the smoke and that the presence of sulphurous acid, sulphuric acid and carbonic acid was not discernable except in the outside 1 cm. (3/8 inch) layer of the concrete. In view of these results the conclusion was come to that a coating in concrete 3 cm. (1 3/16 inch) thick was sufficient to guarantee the reinforcement against the action of the smoke provided the concrete was as compact as possible.

The chemical analysis confirms the general opinion given above on the subject of the action of locomotive smoke upon concrete.

Belgrade, 12 May 1929.

[ 621. 335 ]

# REPORT No. 4

**(All countries except America, the British Empire, China, Japan, France and its Colonies).**

## ON THE QUESTION OF ELECTRIC LOCOMOTIVES FOR MAIN LINE TRACTION (SUBJECT VII FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION (1) (2),

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Figs. 1 to 53, pp. 3000 to 3043.

### I. — Introduction.

The following report has been drawn up in accordance with the particulars sent by the following railway companies, in response to a questionnaire which had been addressed to them :

*Spain* : Andalusian Railways. — North of Spain Railways.

*Italy* : State Railways. — North of Milan Railway.

*Norway* : State Railways.

*Sweden* : State Railways.

*Switzerland* : Federal Railways. — Bernese Alps Railways.

*Czecho-Slovakia* : State Railways.

The principal data concerning the locomotives considered are grouped in the appendix.

On the Companies touched by the inquiry, all systems of traction are met with, single phase at 15 000 volts, continuous current at 650, 1 500 and 3 000 volts, and three phase at 3 700 and 10 000 volts, so that the electric locomotives which have been examined present, by reason of this fact alone, very wide differences which remain even when it is a question of locomotives on the same system. It has therefore been thought indispensable to confine the present report to a small number of considerations, which, being applicable to locomotives of different systems, would permit conclusions to be arrived at having a certain character of general application.

With regard to the different systems of current supply and the different ser-

(1) This question runs as follows : Electric locomotives for main line traction : *a*) passenger locomotives; *b*) goods locomotives; *c*) locomotives for mountainous country. Multiple unit traction.

(2) Translated from the French.

vices for which the locomotives are employed, regarding which data have been furnished to us, the following classification may be established :

| SYSTEM OF CURRENT. | Very high speed locomotives, (above 100 km. [62 miles] per hour). | High speed locomotives (75-100 km. [46.6 to 62 miles] per hour). | Locomotives for speeds up to 75 km. (46.6 miles). | Locomotives for goods or mountain traffic. (50-65 km. [31 to 40.4 miles] per hour). | Tota. |
|---|---|---|---|---|---|
| Single phase 15 000 volts, 16.7 periods. | 24 | 265 | 73 | 85 | 447 |
| Continuous 3 000 volts. | 2 | ... | 6 | 20 | 28 |
| Continuous 1 500 volts. | 12 | 28 | ... | 9 | 49 |
| Continuous 650 volts. | ... | 17 | 5 | ... | 22 |
| Three hase. 3 700 volts, 16.7 periods. | ... | 117 | 46 | 568 | 731 |
| Three phase 10 000 volts, 45 periods. | ... | 14 | 10 | 4 | 28 |
| Total . . . . | 38 | 441 | 140 | 686 | 1 305 |

The extent of the electrified lines on which the locomotives considered are in service, according to the information given by the Administrations which have replied to the questionnaire, was the following at the end of 1928 :

| RAILWAY. | Single phase 15 000 volts | Continuous current. | | | Three phase | | | Total. |
|---|---|---|---|---|---|---|---|---|
| | | 3 000 volts | 1 500 volts | 650 volts | 3 700 volts | 5 500 volts | 10 000 volts | |
| Andalusian Railways . . | ... | ... | ... | ... | ... | 30 | ... | 30 |
| North of Spain Railways . | ... | 62 | 170 | ... | ... | ... | ... | 232 |

| RAILWAY | Single phase 15 000 volts | Continuous current | | | Three phase. | | | Total. |
|---|---|---|---|---|---|---|---|---|
| | | 3 000 volts | 1 500 volts | 650 volts | 3 700 volts | 5 500 volts | 10 000 volts | |
| talian State Railways. . | ... | 101 | ... | 108 | 1 365 | ... | 172 | 1 746 |
| orth of Milan Railways, Italy. . . . . . . . | ... | 44 | ... | ... | ... | ... | ... | 44 |
| orwegian State Railways . . . . . . . | 144 | ... | ... | ... | ... | ... | ... | 144 |
| wedish State Railways . | 916 | ... | ... | ... | ... | ... | ... | 916 |
| wiss Federal Railways . | 1 666 | ... | .. | ... | ... | ... | ... | 1 666 |
| ernese Alps Railways . | 255 | ... | ... | ... | ... | ... | ... | 255 |
| zecho-Slovakian State Railways . . . . . . | ... | . . | 25 | ... | ... | ... | ... | 25 |
| Total. . . . | 2 981 | 207 | 195 | 108 | 1 365 | 30 | 172 | 5 058 |

### A. — General questions concerning the mechanical portion of all the types of locomotives.

#### 1. System of transmission of the movement of the motors to the wheels.

From this point of view, the locomotives considered present the greatest variety of solutions.

a) *Direct drive by gearing* (fig. 1).

This system, generally employed on tramways, is also widely applied and gives very good results on locomotives in which it is convenient to split up the motive power; this is the case with the low speed and medium speed continuous current locomotives working at various voltages examined in this report. The power of each motor is as much as 360 kw.,

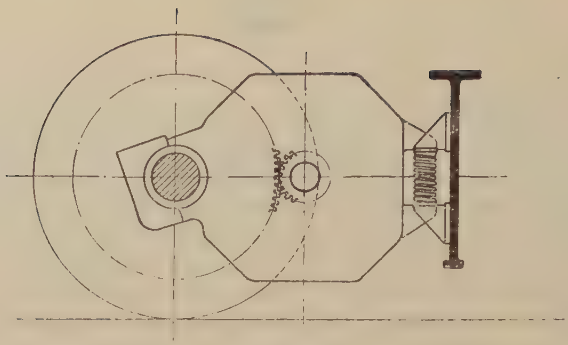


Fig. 1.

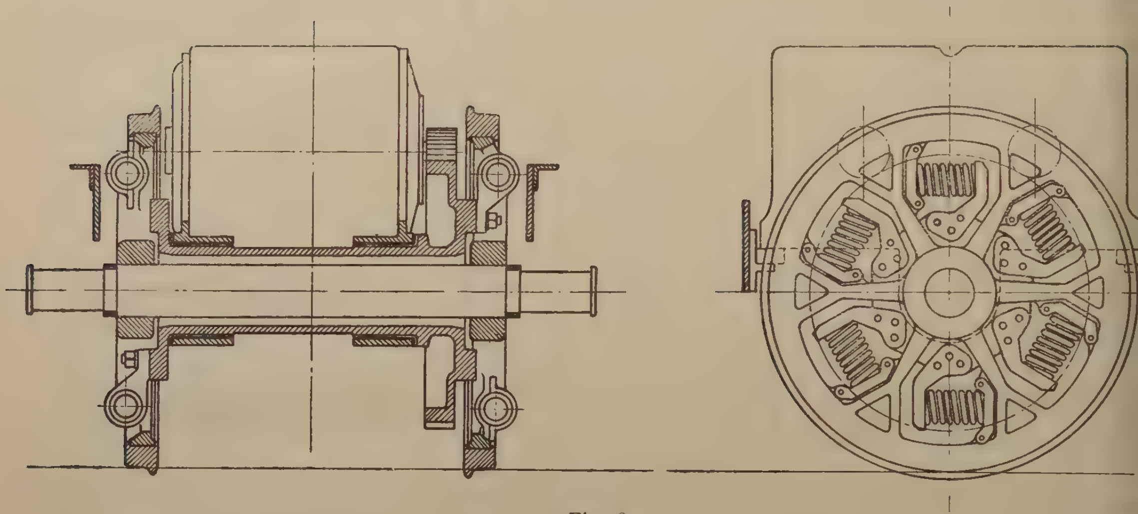


Fig. 2.

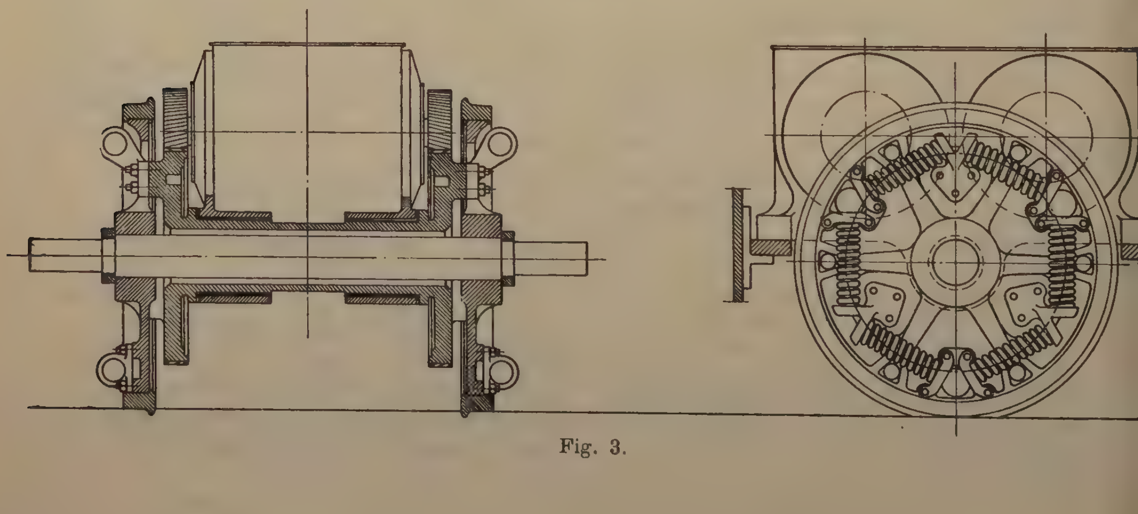


Fig. 3.

and the weight 4 200 kgr. (9 260 lb.), of which approximately half is carried directly by the axle. The weight per axle does not exceed 16.5 t. (16.3 Engl. tons). The transmission is in general unilateral, and the large gear wheel is sometimes provided with springs.

The use of elastic gears, however, appears preferable to the use of rigid gears when the power and the weight per axle become greater.

In all cases, the nose of the motor is suspended from the chassis by springs.

If the transmission of the motion is bilateral, the teeth of the gears are inclined. It is generally preferred to fasten the large gear wheel directly to the wheel centre, instead of on the axle.

This system of transmission is adopted on the locomotives $C_0$ — $C_0$, $C_0 + C_0$ and 1 $C_0 + C_0$ 1 of the North of Spain Railway, on the $B_0 + B_0 + B_0$ and $C_0 + C_0$ of the Italian State Railways, and on the 1 $A_0 + B_0 + A_0$ 1 and $B_0$ — $B_0$ of the Czecho-Slovakian State Railways. With the arrangement of motors suspended by the nose, the criticism has sometimes been made that the position of the centre of gravity is too low, also that there is a possibility of reaction of the wheels on the rails and abnormal stresses on the gearing.

Experience has shown, however, that the above objections are negligible if the speed and the weight per axle are also limited.

Mention has also been made of the necessity, during the winter, of taking precautions to prevent snow from penetrating into the interior of the motors.

On the other hand, this arrangement of the motors presents the advantage of great simplicity, and it facilitates the location of the electric switchgear, for which the whole of the inside of the body is available.

b) *Individual drive by gearing and hollow shaft.*

The systems differ by the means employed to couple the hollow shaft to the driving wheel.

In the arrangement represented in figure 2, applied on the locomotives A*e* 3/6, A*e* 3/5 and B*e* 4/7 of the Swiss Federal Railways, the origal Westinghouse arrangement is reproduced, in which the elastic device is constituted by helical springs.

The system represented in figure 3 is applied to the locomotives 1 $C_0 + C_0$ 1 of the Lötschberg Railways. Compared with the foregoing one, it enables the length of the springs to be increased, the diameter of the driving wheels to be reduced, and the number of points at which the springs are attached to the hollow shaft and to the wheel to be halved.

Figure 4 represents the system which has been applied to the trial high-speed locomotives 2 $C_0$ 2, 3 000 volts continuous current, of the Italian State Railways.

The transmission of the power from the hollow shaft to the driving wheel is effected by means of plate springs of equal length, arranged radially.

These springs are articulated by means of pivots to the hollow shaft, so as to be capable of oscillation in a plane which passes through the axle.

The buckles have, inside the opening for the plates (see *a*), a curved surface on which the spring plates bear when the flexion exceeds a predetermined value, so as to limit the maximum load on the plates.

c) *Brown-Boveri drive.*

This system, represented diagrammatically in figure 5, is employed on the high-speed single phase locomotives A*e* 3/6 and A*e* 4/7 of the Swiss Federal Railways, and on the continuous current locomotives

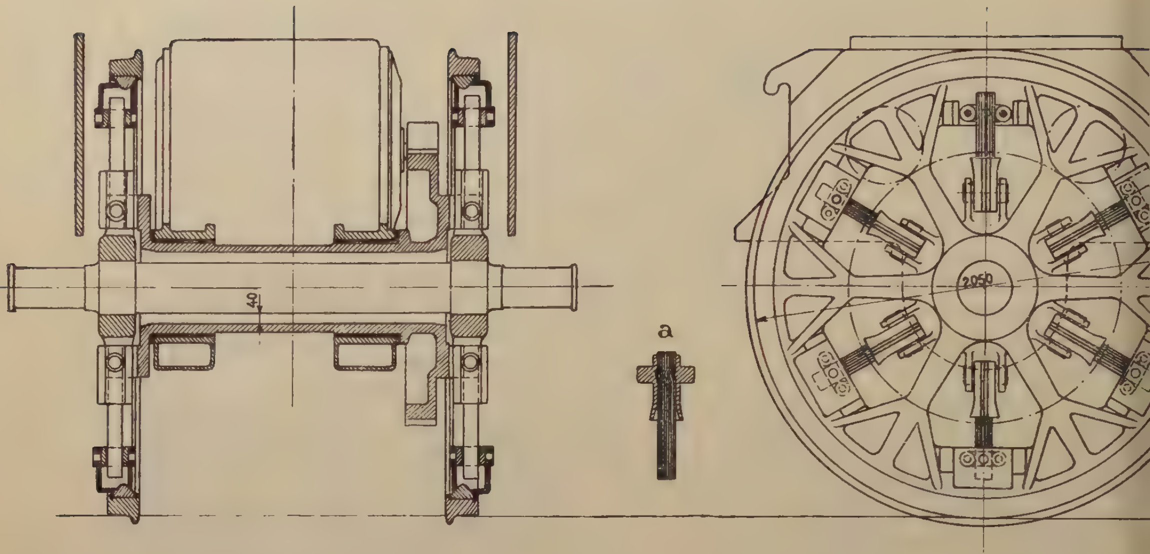



Fig. 4.

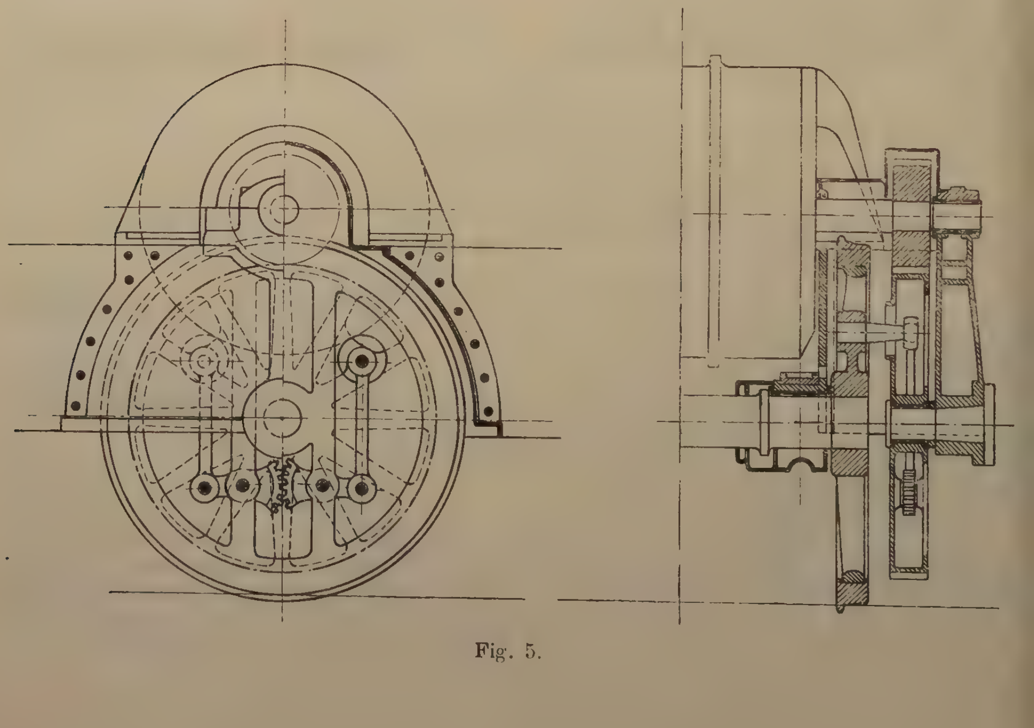


Fig. 5.

type 7 200 of the North of Spain Railways, either with double gearing or with unilateral gearing.

d) *Drive by gearing and connecting rods.*

This is generally used when there are one or two traction motors and several axles.

The system with triangular connecting rod, which connects the axle cranks to the gear wheel shafts, is used on the locomotives A*e* 3/6 of the Swiss Federal Railways, and on the B*e* 5/7 type of the Lötschberg Railways, as well as on the locomotives E 470, E 472 and E 570, three phase industrial frequency type, of the Italian State Railways (fig. 6).

In the case of the locomotives C*e* 6/8 II, of the Federal Railways, one of the cranks of the triangular connecting rod is a driver, while the other is merely a bearer, (see fig. 7).

When the distance between two axles is sufficiently great to allow of the motors and gearing being placed between them, keeping the gearing shaft at the same level as the wheels, we have the arrangement indicated in figure 8.

This arrangement has been adopted in the locomotives B*e* 4/6 of the Federal Railways, P*b*, O*c*, O*d*, O*e*, O*f*, D of the Swedish State Railways, and B + B, 1 B + B 1, 1 C + C 1 of the Norwegian State Railways.

e) *Connecting rod system.*

Connecting rods are employed on single phase locomotives of the Swedish State Railways, on the generality of the 16.7 period three-phase locomotives, also on some of the continuous current low tension locomotives of the Italian State Railways.

The motors, running at slow speed, are generally large in diameter and are necessarily placed well above the driving wheels; the transmission is effected by means of triangular connecting rods or a jack shaft (fig. 9). This latter is used on the single phase locomotives P*a*, O*a* and O*b* of the Swedish State Railways, and on the locomotives E 331 and E 332, three-phase type, of the Italian State Railways.

The triangular connecting rod system is used on the generality of the three phase locomotives of earlier construction, while on 12 locomotives E 552 and E 471 the Kando connecting rod system (fig. 10) is employed, and on 223 locomotives E 554 and E 432, recently constructed, the Bianchi connecting rod systems represented in figures 11 and 12 have been used.

The use of articulated connecting rods presents advantages over that of the triangular connecting rods, because it is possible to install the motors at a sufficient distance from the wheel axles without the weight of the whole of the transmission becoming excessive, as it would if triangular connecting rods or a jack shaft were employed.

The stresses in the articulated connecting rods being statically determined, it is possible to proportion these parts with accuracy and to secure greater lightness, even for the counterweights of the crankshafts of the motors and of the wheels.

**2. Arrangement of the trucks, the bodies and the electric switchgear.**

With regards to the types of trucks adopted, the locomotives forming the subject of the present report may be classed as follows :

*a*) Total adhesion and rigid frame locomotives;

*b*) Total adhesion and articulatied truck locomotives (several trucks with driving axles)

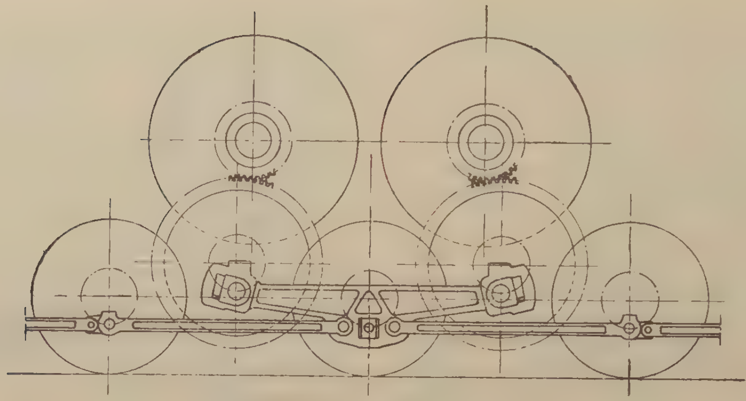


Fig. 6.

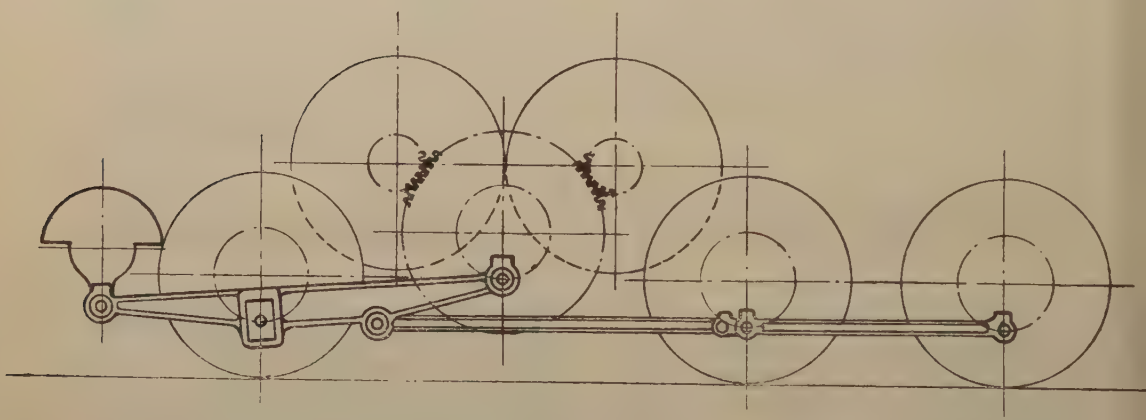


Fig. 7.

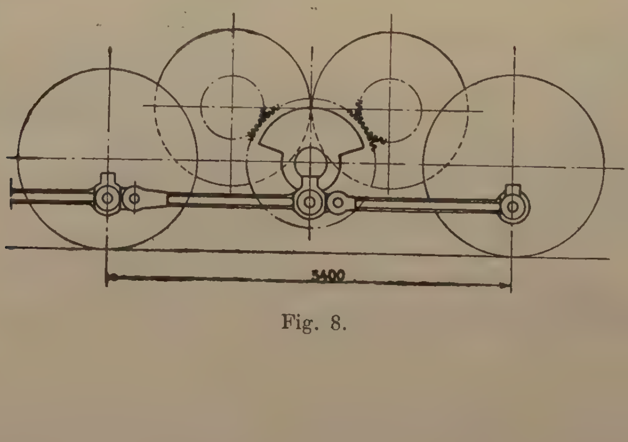



Fig. 8.

*c)* Locomotives with driving and carrying axles mounted on a single main frame;

*d)* Locomotives with driving and carrying axles and articulated trucks.

a) *Total adhesion and rigid frame locomotives.*

Amongst the locomotives belonging to this class are the single phase type *o*D*o* (series O*d* of the Swedish State Railways (fig. 13), and the three phase types *o*E*o* (E 550, E 551, E 552, E 554 and E 570) of the Italian State Railways (fig. 14).

The total wheel base of these locomotives runs up to 6.60 m. (21 ft. 8 in.); axles 1 and 5 have a lateral play of 15 mm. (5/8 inch) on each side, and the wheels of axle 3 are flangeless. The rigid wheel base (distances between axles 2 and 4) amounts to 3.84 m. (12 ft. 7 3/16 in.).

These locomotives, of which there is a large number (571 units) are used for goods and mountain district service.

The weight per axle is limited to 17.25 t. (17 Engl. tons) and the maximum speed to 60 km. (37.3 miles) per hour, for the locomotives *o*E*o* of the Swedish State Railways, and to 16 t. (15.7 Engl. tons) and 50 km. (31 miles) for the three phase locomotives *o*E*o* of the Italian State Railways. Practical experience has demonstrated that, provided the limits are not exceeded, the results are completely satisfactory, from the point of view of regularity of running and of the stresses exerted on the rails.

b) *Total adhesion and articulated truck locomotives (several bogies with driving axles).*

The Swedish and Norwegian State Railways have in service B + B type locomotives, having a motor for each bogie which, by means of gearing and con-

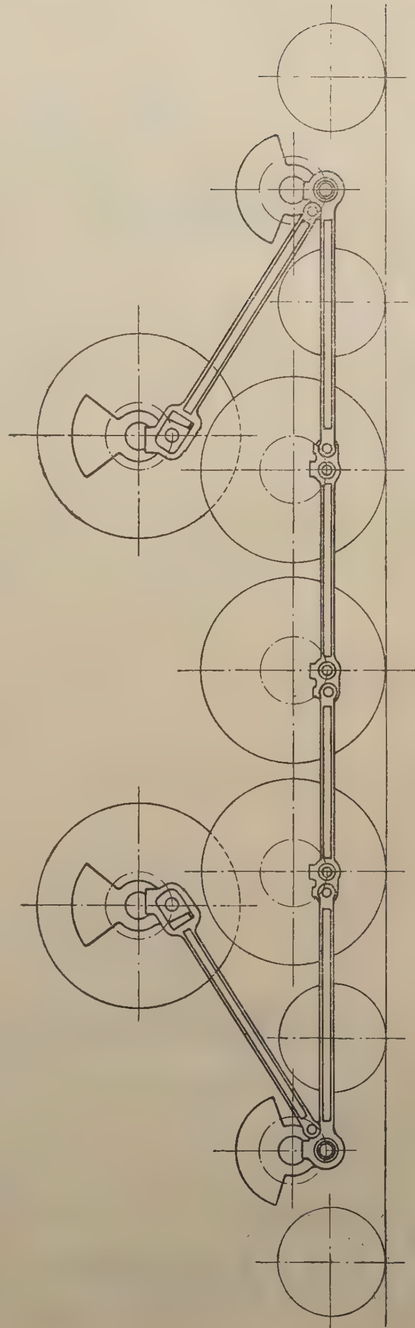


Fig. 9.

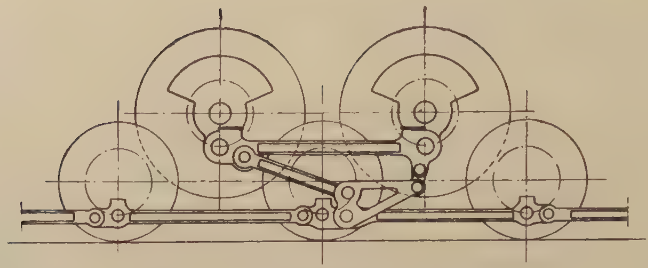


Fig. 10.

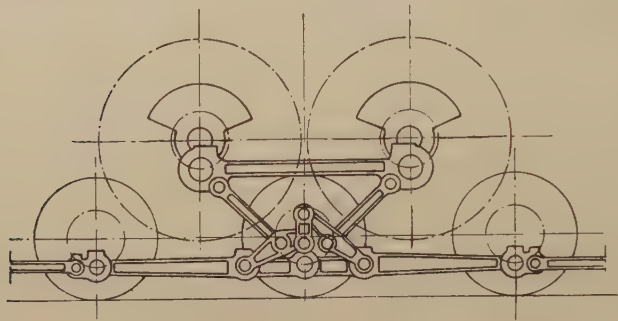


Fig. 11.

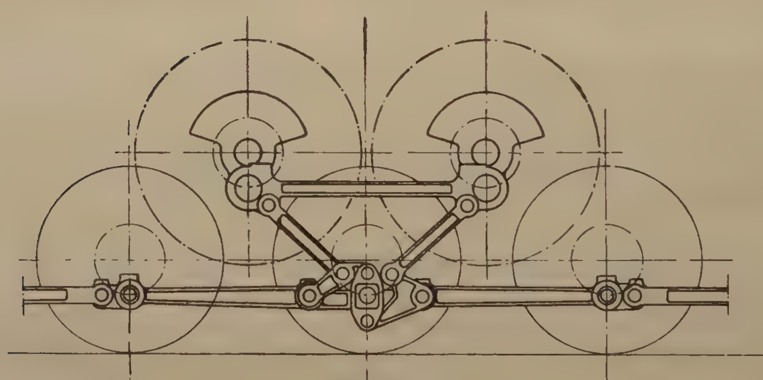


Fig. 12.

necting rods, actuates the driving wheels (fig. 15).

The speed does not exceed 60 km. (37.3 miles) per hour.

Amongst the continuous current locomotives, the arangement with motors suspended by the nose is generally adopted. The types most widely in use have the arangement $B_0 - B_0$ or $B_0 + B_0$ (locomotives 2 500 of Norway, of the

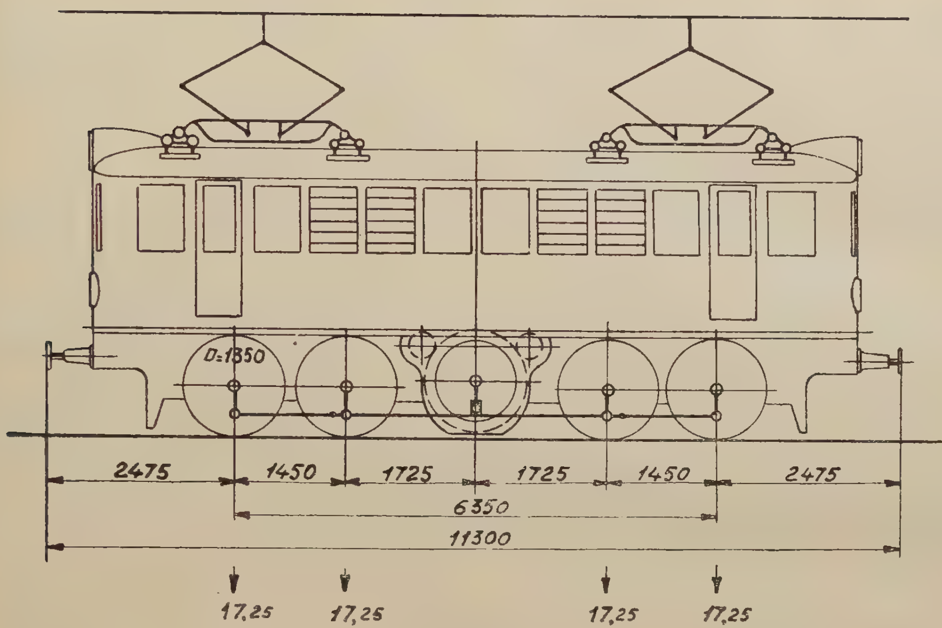

D=1350
2475
1450
1725
1725
1450
2475
6350
11300
17,25
17,25
17,25
17,25

Fig. 13.

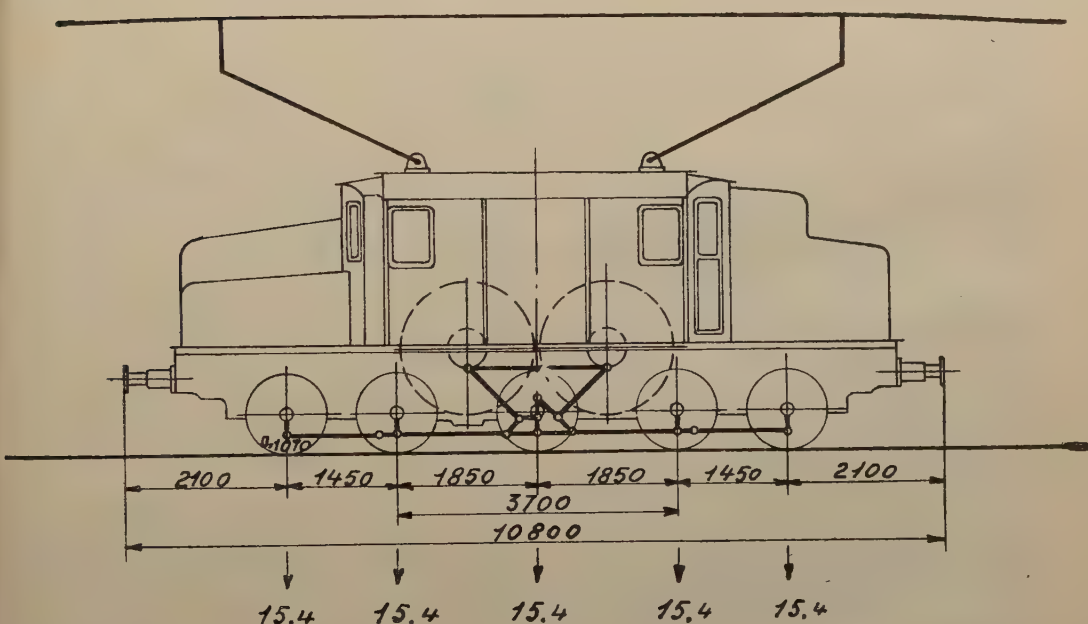

D=1070
2100
1450
1850
1850
1450
2100
3700
10800
15.4
15.4
15.4
15.4
15.4

Fig. 14.

North of Milan [fig. 32], E 420 of the Italian State Railways [fig. 16], and 423, 424, 436 and 466 of the Czecho-Slovakian State Railways), or else $C_0$—$C_0$ or $C_0+C_0$ (locomotives 6 000, 6 100 and 7 000 of the North of Spain Railways [fig. 17], or finally $B_0 + B_0 + B_0$ (locomotives E 625 of the Italian State Railways [fig. 33]).

Where the draw gear and buffer gear are fixed to the front buffer beams of the bogies, the latter are also connected together so as to permit rotation in all directions, but not longitudinal movement between the two bogies thus connected. To prevent the efforts transmitted from one bogie to another in the vertical direction having the effect of altering the weight on the axles, the springs of each bogie are often connected by means of equalisers. In the locomotives $C_0$ — $C_0$, type 6 000, of the North of Spain, the spings act at the same time as balance beams (fig. 18).

In the locomotives $B_0 + B_0 + B_0$, already cited, of the Italian State Railways, the end bissel trucks which carry the buffers and drawbar gear are coupled to the main frame, to which the body is fixed, by doubly articulated triangular radius bars which permit of relative displacements between the frames. These displacements, however, are limited vertically by the fact that the sole bars of the leading frame are extended and fit into openings cut in the soles of the main frame. Spherical couplings limit the amplitude of the changes of level between the two frames (figs. 19 and 20).

The load is distributed between the central axles and the axles of the leading bissel trucks by means of long longitudinal equalisers. Each equaliser rests on the headstock of the leading frame through the intermediary of a pivot provided at its end with a roller which can roll on inclined planes provided on the headstock. The relative displacements of the frames are thus made possible, a self-centring action also being provided which action is slightly augmented by plate springs bearing on a detail of the main frame.

For the locomotives with motor bogies and with motors suspended by the nose considered in the present report, the maximum speed may attain 80-90 km. (49.7-55.9 miles) per hour, even in the case of locomotives the total weight of which is available for adhesion. We know, however, that certain locomotives of this type, provided with leading trucks and which belong to Administrations not members of the Railway Congress Association, can attain speeds higher than 100 km. (62 miles) per hour.

c) *Locomotives with motor and carrying axles mounted in a single frame.*

When the speed to be attained exceeds 60 km. (37.3 miles) per hour, and the locomotive has a single frame, it is considered indispensable to use carrying axles (bissel trucks) to facilitate the inscription on curves, and to give steady running.

When the total wheel base does not exceed 6 m. (20 feet) and the outer or intermediate axles are given side play, the single frame locomotives can run through curves of about 100 m. (5 chains) radius. Locomotives with three and four driving axles for passenger and goods service can be built in this way.

The whole of the three phase passenger locomotives, and the generality of the single phase locomotives, belong to this type.

For the guiding axle either the Krauss-Helmholtz arrangement, or the Zara, or Italian type, or finally bissel trucks are used.

All the types of drive already cited are employed in these types of locomotives.

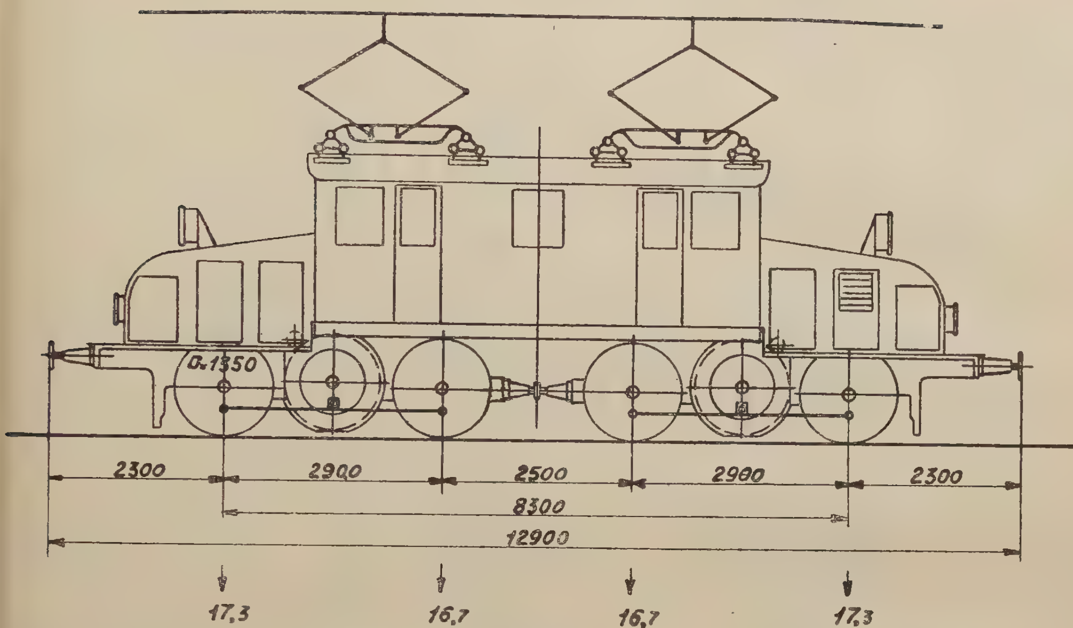



Fig. 15.

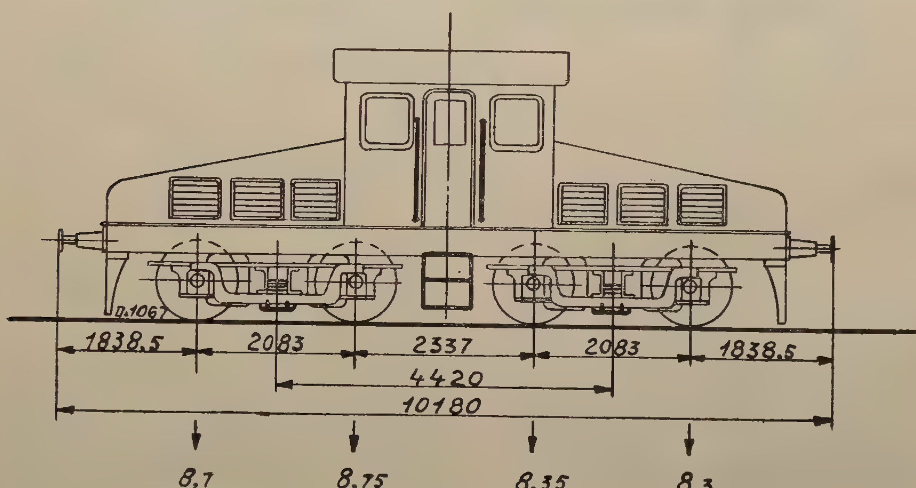



Fig. 16.

As characteristic examples may be mentioned :

Locomotives 2 B 2 (type P*a*) of the Swedish State Railways (fig. 45) and the 1 C 1, 2 C 2, 1 D 1 (types E 330, E 333, E 331, E 332, E 431 and E 432) of the

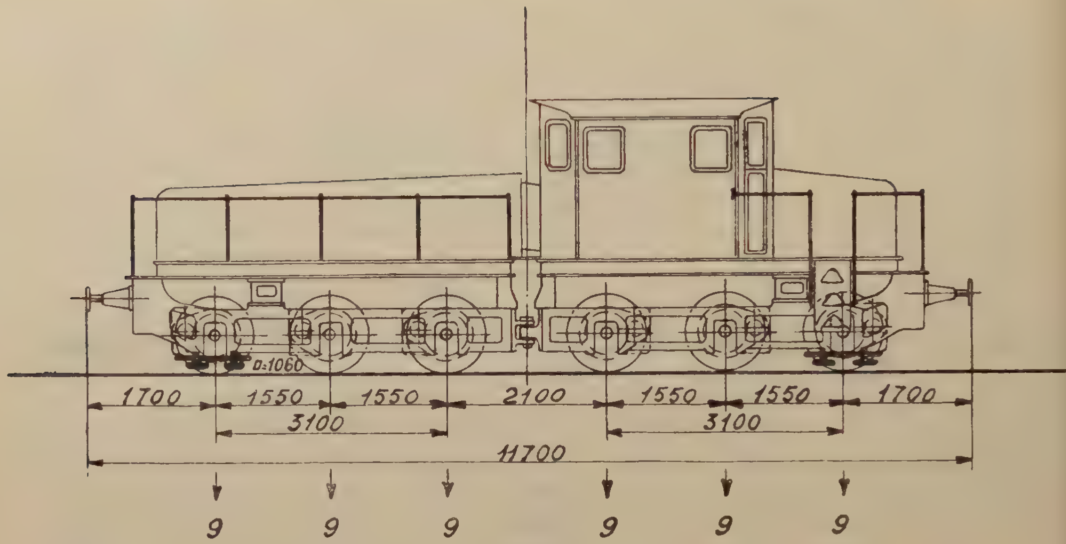



Fig. 17.

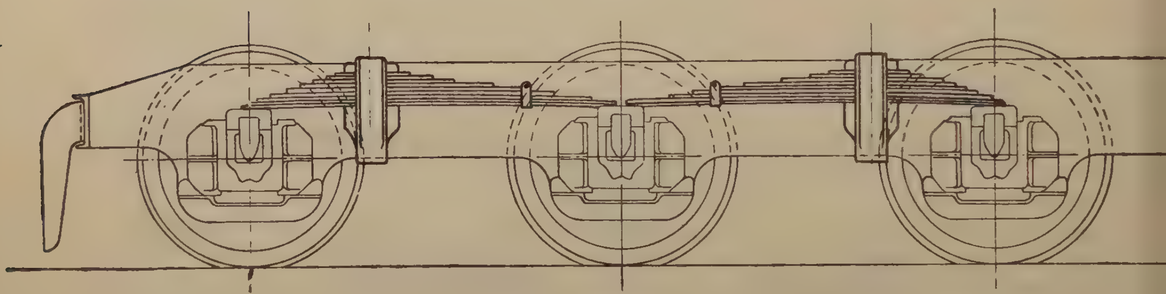


Fig. 18.

Italian State Railways (figs. 34, 35, 36) all having connecting rod drive, the single phase locomotives 1 C 2 (type A*e* 3/6) of the Swiss Federal Railways (fig. 41), 2 B and 1 C 1 of the Swedish State Railways (figs. 22 and 43), and the three-phase 45-period (type E 470, E 472) of the Italian State Railways (fig. 37) having gear and connecting rod drive; the single phase locomotives 1 $C_0$ 1, 1 $C_0$ 2, 1 $D_0$ 2 of the Swiss Federal Railways (figs. 38, 39, 28) and the continuous current locomotives 2 $C_0$ 2 of the Italian State Railways (fig. 30), having the quill or the Brown-Boveri drive.

d) *Locomotives with driving and carrying axles and articulated trucks.*

Articulated trucks are in general employed for the locomotives with 6 driving axles, with the exception of the locomotives 1 B + B 1 of the Federal Railways (fig. 25) and the Norwegian State Railways, and the 2B + B2 of the Swedish State Railways (fig. 44). It must, however, be remarked that in these loco-

motives the gear and rod type of drive is used, which, involving a long wheel base, has made it necessary to use articulated trucks.

The single phase and continuous current articulated locomotives having the arrangement 1C + C1 or $1C_0 + C_01$ or $2C_0 + C_02$ are intended for heavy trains, to pull which great adhesive weight is necessary. The type of drive used is by gearing and connecting rods (single phase locomotives C*e* 6/8 of the Federal Railways (figs. 46 and 47); motors suspended by the nose (locomotives 7 100 of the North of Spain Railways [fig. 31] or by gear and quill (locomotives B*e* 6/8 of the Lötschberg [fig. 40] or B.B. system locomotives 7 200 of the North of Spain Railways [fig. 29]).

With regard to the coupling between the two main trucks, experience has shown the necessity of reducing the vertical and horizontal play as much as possible.

Generally articulated couplings which permit only a rotary movement of the two trucks are preferred.

With this type of locomotive, the cab, is often divided into two parts likewise articulated together. However, articulated cabs make it more difficult to arrange the electric switchgear; consequently when possible, a single cab is preferred, carried on one of the trucks on a ball joint permitting rotation only, and on the other by means of a ball joint permitting also longitudinal movement. At the sides, they are carried on friction blocks or ball joints, or on plate or helical springs.

The buffer and draw gear are always carried on the trucks and not on the bodies.

As concerns the arragement of the bodies and of the switchgear, the different

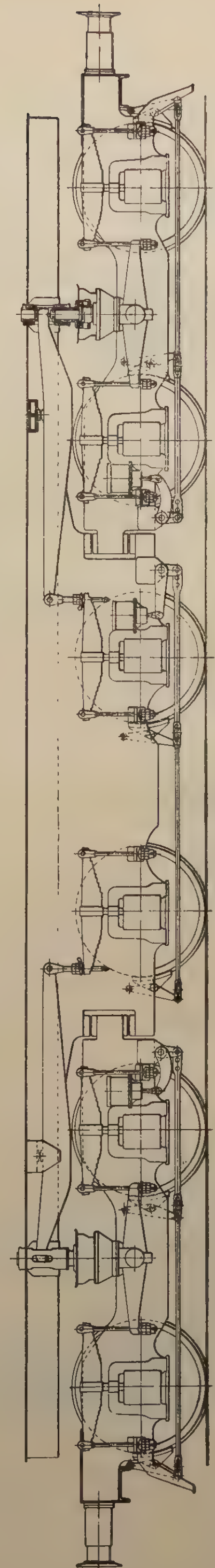
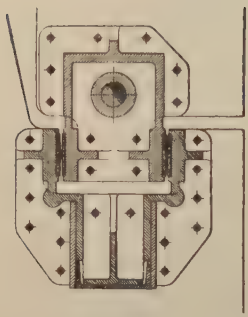
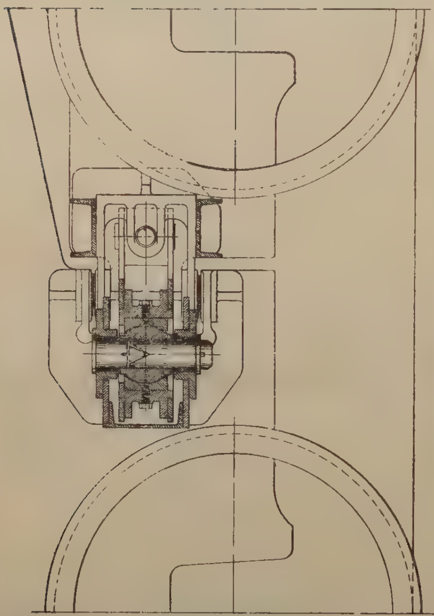


Fig. 19.





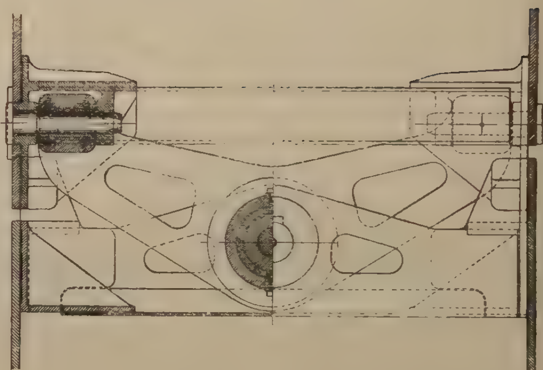


Fig. 20

companies were asked to indicate the arrangements to be preferred.

The replies which have reached us place on evidence the advantages and disadvantages of the following arrangements (fig. 26).

*Type A.* — Two drivers' cabins at the ends, and central compartment containing the switchgear, having two corridors at the sides. This arrangement is adopted for the single phase, three phase and continuous current locomotives.

*Type B.* — Arrangement as A, but with bonnets at the ends (containing the compressors, fans, rheostats, tools, etc.).

This arrangement is adopted on almost the whole of the three phase locomotives (in which there is, however, no

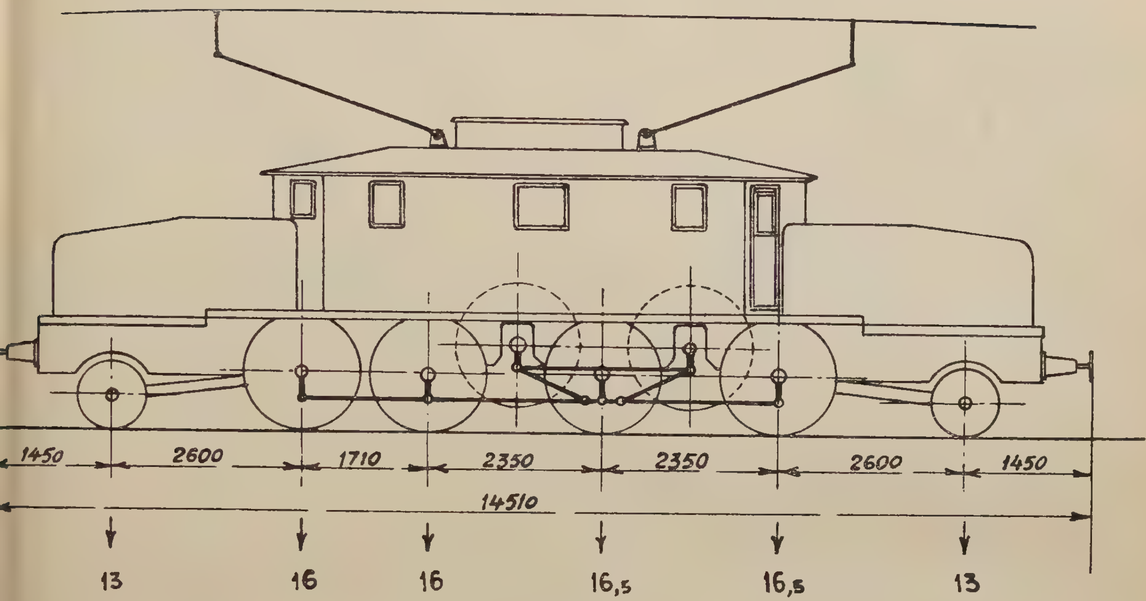

1450
2600
1710
2350
2350
2600
1450
14510
13
16
16
16,5
16,5
13

Fig. 21.

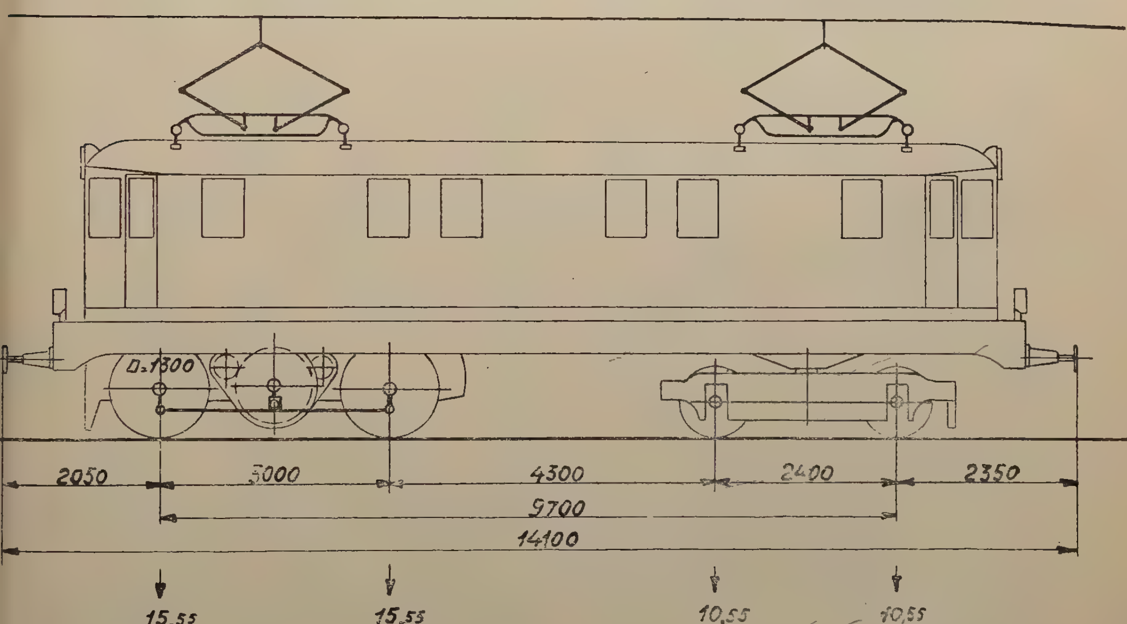

D=1300
2050
3000
4300
2400
2350
9700
14100
15,55
15,55
10,55
10,55

Fig. 22.

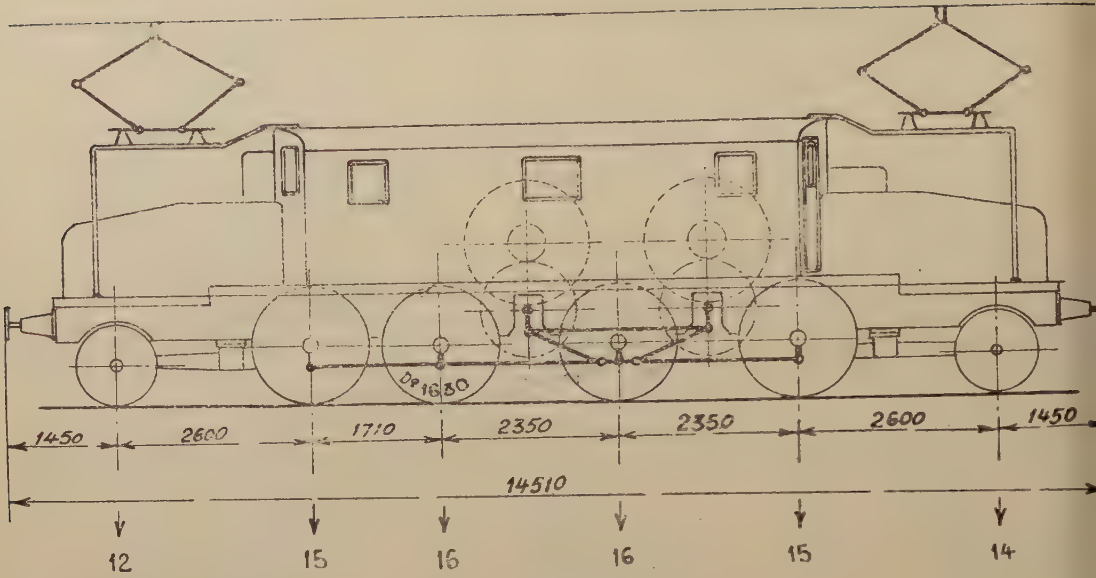



Fig. 23.

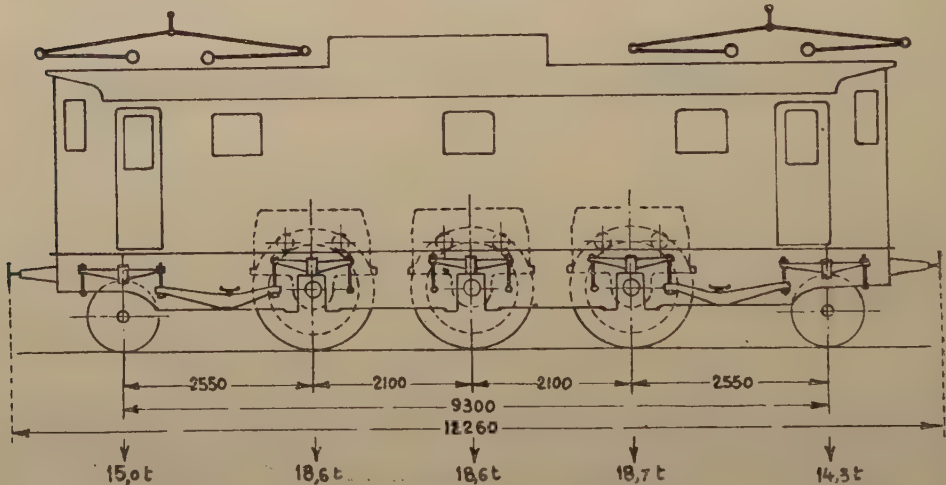



Fig. 24.

division between the central cab and that of the driver) and on several single phase and continuous current locomotives.

*Type C.* — Adopted only on the Ce 6/8 locomotives of the Swiss Federal Railways.

*Type D.* — Adopted only on the three phase locomotives of the Italian State Railways. This arrangement gives, on

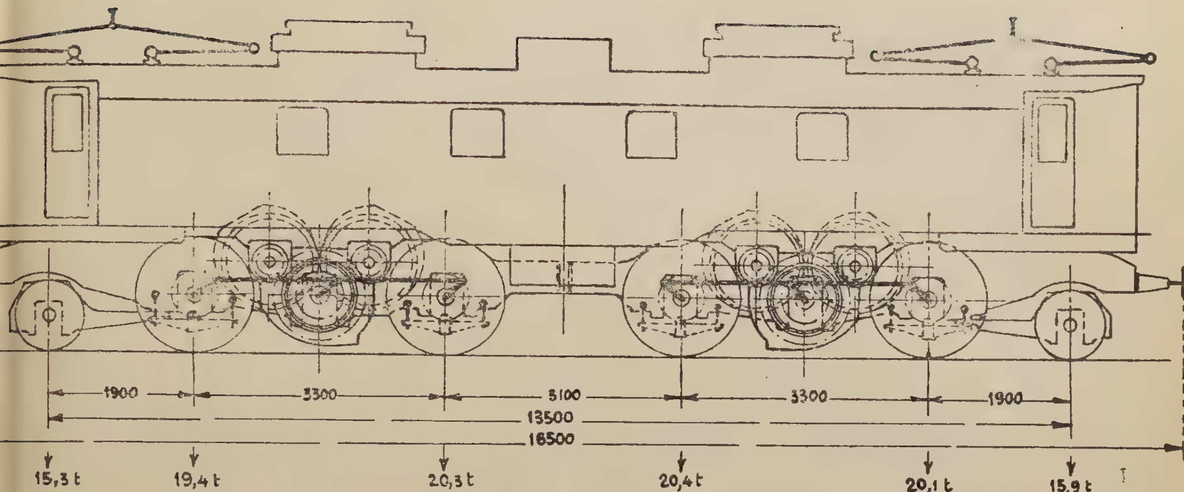



Fig. 25.

the one hand, a very spacious driver's cab, but from the point of view of the possibility of supervision of the switchgear during running, it is not considered as better than the others.

The arrangements A and B, except for small variants, are therefore preferred owing to the fact that the driver has a very good lookout, while at the same time it is possible to supervise during running the apparatus enclosed in the central cab. Noisy apparatus (compressors, fans, motor generators) or those presenting danger for the staff (switches, fuses, etc.) are enclosed under the bonnets.

### 3. Arrangement of the wheels.

To indicate the arrangement of the wheels, preference has been given to the notation in which the carrying axles are indicated by figures, while the motor axles are indicated by letters, followed by an index cypher if the axle has individual drive. For locomotives with bogies or articulated trucks the sign + or — has been adopted, according to whether the bogies or the trucks are or are not coupled directly together.

The arrangement adopted for the wheels of each type of locomotive considered is indicated in the appendix.

Amongst the single phase locomotives there are to be noted all possible arrangements of the wheels, *i. e.*: *o* D *o*, 1 $C_0$ 1, 1 $C_0$ 2, 1 C 2, 1 $D_0$ 2, 1 E 1, 2 B 2, 2 B O, B + B, $B_0$ + $B_0$, 1 B + B 1, 1 $B_0$ + 1 $B_0$ 1, 2 B + B 2, 1 C + C 1, 1 $C_0$ + $C_0$ 1, and all systems for the transmission of motion between the motors and the wheels.

In the continuous current locomotives, the following arangements are employed: $B_0$ — $B_0$, $B_0$ + $B_0$, $B_0$ + $B_0$ + $B_0$, $C_0$ — $C_0$, $C_0$ + $C_0$, 1 $A_0$ + $B_0$ + $A_0$ 1, 1 $C_0$ + $C_0$ 1, 2 $C_0$ + $C_0$ 2, 2 $C_0$ 2, amongst which the articulated and bogie types with individual axle drives are clearly preponderant.

Only the 650-volt continuous current locomotives of the Italian State Railways, types E 320, E 321, present the arrange-

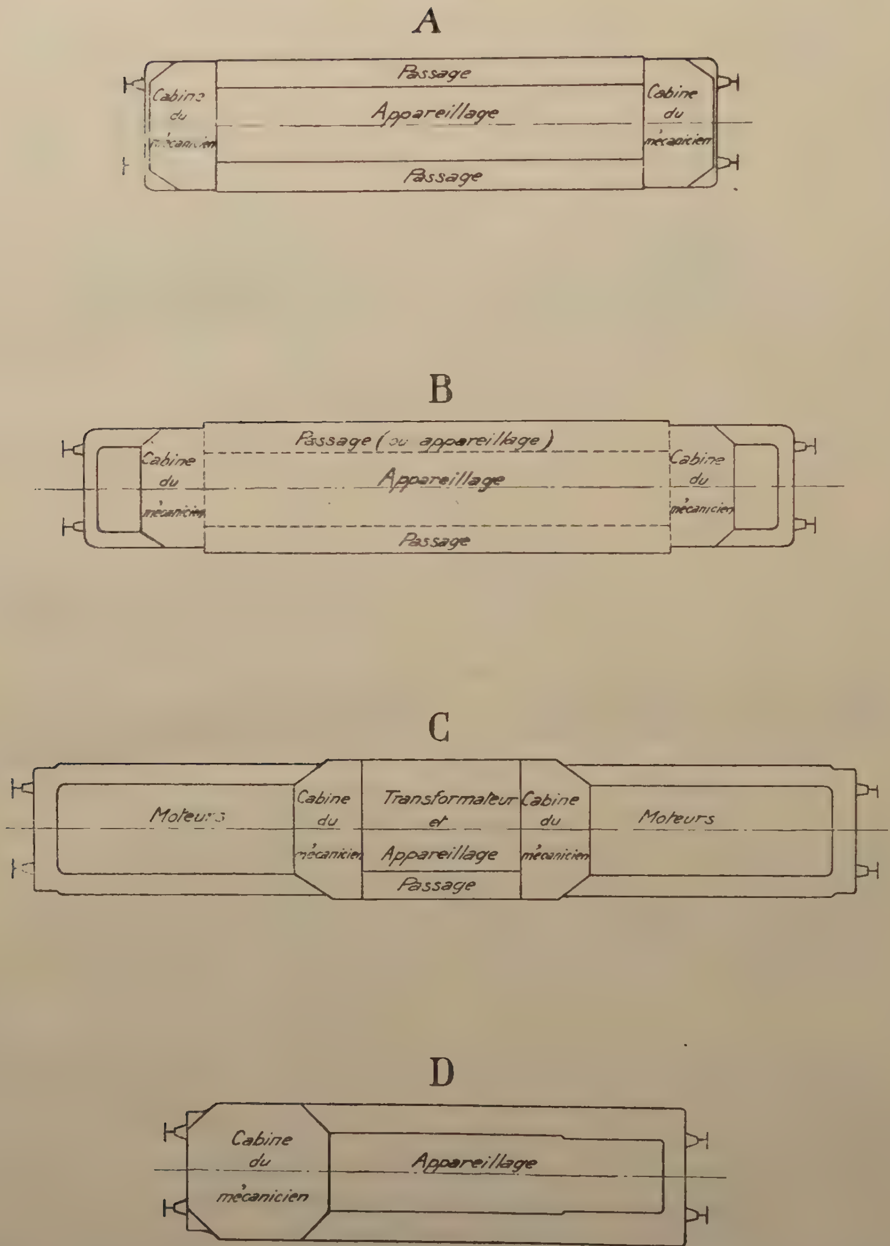



Fig. 26.

*Explanation of French terms*: Appareillage = Apparatus. — Cabine du mécanicien = Driver's compartment. — Moteurs = Motors. — Passage (ou appareillage) = Passage (or apparatus). — Transformateur et appareillage = Transformer and apparatus.

ment 1C1 with connecting rod transmission.

In the 3 700 and 10 000 volt three phase locomotives, the arangements adopted are : 0E0, 1C1, 2C2, 1D1, and in all we have connecting rod drive or gearing and connecting rod drive.

In this case, the locomotives are never built with articulated trucks.

To facilitate their inscription in curves of small radius, one or two pairs of wheels are given side play. It should, however, be pointed out that, in some types of locomotives in which all the driving wheels were given side play it was subsequently found necessary to give such play to a minimum number of wheels and to make it as small as possible, to prevent rolling at high speeds.

In the locomotives considered, the lateral displacement of the bogie pivots does not exceed 150 mm. (6 inches) on each side, while that of the carrying axles has a maximum of 100 m. (3 15/16 inches).

The lateral displacement of the driving axles never exceeds 25 mm. (1 inch) on each side.

#### 4. Weight per axle, per metre of length and of total wheel base.

It is generally recognised that when getting out the design of a locomotive, the value of the maximum weight admissible per axle is of great importance.

However, a slightly greater weight per axle is admitted for electric locomotives than under the same conditions for steam locomotives.

From this point of view, the electric locomotives with independant axles and with raised centre of gravity are the best.

The locomotives considered present remarkable differences from the point of view of the weight per axle.

Whereas this weight is contained within fairly close limits in the case of the Swedish locomotives (15.55 — 17.5 t. [15.30 — 17.22 Engl. tons]) and the Swiss locomotives (16.9 — 20.4 t. [16.63 — 20.07 Engl. tons]), it is very variable (12.6 — 21 t. [12.40 — 20.67 Engl. tons]) in the Italian locomotives.

In the circumstances, it has been thought necessary not to make comparisons between the total weight and the weight per unit of power.

Less divergent are the figures relating to the value of the weight per metre over buffers and per metre of wheel base. The former is, in general, limited between 5 and 7 t. (1.5 and 2.1 Engl. tons per foot), with a maximum of 7.4 (2.2 Engl. tons per foot) (type 0*b* of the Swedish State Railways), the latter between 7 and 9 t. (2.1 and 2.7 Engl. tons per foot), with a maximum of 9.4 (2.8 Engl. tons per foot (locomotive 0*b* already cited).

#### 5. Adhesive factors (1).

Amongst the locomotives with individual axle drive, the adhesive factor in relation to the one-hour rating (ratio between the one-hour rating and the adhesive weight) is comprised between 1: 4.7 (locomotive B*e* 6/8 of the Bernese Alps Railways), and 1: 7.5 (3 000-volt continuous current locomptives of the Italian State Railways).

The adhesive factor in relation to the continuous rating is comprised between 1: 5.5 (locomotive B*e* 6/8 already named)

(1) As will be seen on page 3024, the various countries have not yet adopted uniform temperature limits for the hour and the continuous power ratings of their traction motors and the figures given as the coefficients of adhesion are therefore not exactly comparable.

and 1 : 9 in the case of several single phase and continuous current types. The adhesive factor in relation to the maximum effort is comprised between 1 : 3.4 (locomotive B 6/8) and 1 : 5 approximately.

In the locomotives with coupled wheels drive, the adhesive factor in relation to the hourly rating is comprised between 1 : 4.6 (three phase locomotive E 432 of the Italian State) and 1 : 6.8 in the case of several single phase locomotives.

The adhesive factor in relation to the continuous rating is comprised between 1 : 5.1 (three phase locomotive) and 1 : 9.4 (single phase locomotive). The ratio between the maximum effort and the adhesive weight in the case of three phase locomotives often exceeds the value 1 : 2, thus being above the practical limit of adhesion.

It will be noted in general that the adhesive factors adopted are almost the same for locomotives with individually driven axles and those with the axles coupled.

In the locomotives with motors suspended by the nose, in particular, there has often been reported a reduction of the adhesive weight for the axles having the motor at the rear relatively to the direction of running, and an increase for the axles having the motor in front. This variation of weight is greater for the low-speed high power locomotives with limited weight per axle, and it may produce slipping, especially in the case of the motors being connected in pairs in series.

Even in locomotives with the axles independently driven, having the motors carried rigidly on the frame, several administrations have reported that the factor of adhesion may easily attain the value 1 : 3, *i. e.* a value exceeding that used under the same conditions on steam locomotives.

### 6. Lubrication.

The systems of lubrication of the axle journals and of the connecting rod bearings only differ very slightly from one another, and from those normally used in the case of steam locomotives.

It is, however, to be remarked that on locomotives of recent construction central lubrication systems have been used, operating by means of multiple element pumps which feed through piping the journal boxes of the axles and of the motors, the bogie pivots and sometimes even the connecting rod bearings.

The lubrication of the slow speed motor axles is often effected by rings which dip into the oil. If the number of revolutions is higher, the lubrication is by wool waste packing soaked in oil bearing on the shaft in the region of minimum pressure.

The lubrication of the gearing is generally obtained by oil bath or grease reservoir. The latter system has the advantage over oil of reducing the leakage from the cases over the pinions and spur wheels, and which are generally divided into two.

Roller or ball bearings have not yet come into current use, except for the motors of the auxiliaries.

In all types of electric locomotives it is noted that the systems of lubrication, although they do not present any essential novelties, are very carefully designed, both from the point of view of reliability of operation and from the point of view of economy.

With regard to the total consumption of lubricating material, by the different parts of the locomotive, or as a total per locomotive-kilometre, the different administrations have communicated figures which are all much alike. For the locomotives with three driving and three

carrying axles, the consumption of lubricating materials is between 14.3 and 18.7 grammes per locomotive-kilometre (0.81 and 1.06 ounces per locomotive-mile), according to type, in the case of the Swiss Federal Railways, while for the locomotives with four driving axles and two or three carrying axles the consumption is between 14.1 and 21.4 grammes (0.80 to 1.21 ounces per mile).

For locomotives with six driving and two carrying axles, the consumption is 22.5 grammes (1.28 ounces per locomotive-mile).

For the three-phase locomotives with three driving and two carrying axles the consumption is 14 grammes per locomotive-kilometre (0.79 ounce per locomotive-mile); for four motor and two carrying axles and for five motor axles it is 22 grammes (1.25 ounces per locomotive-mile).

The North of Spain Railways, for $C_0$ — $C_0$ continuous current locomotives, have given the following figures :

6 motors, 7.5 grammes per locomotive-kilometre (0.42 ounce per locomotive-mile);

12 axle-journals, 4.8 grammes per locomotive-kilometre (0.27 ounce per locomotive-mile);

6 pairs of gears, 15 grammes per locomotive-kilometre (0.85 ounce per locomotive-mile).

### 7. Brake equipment.

The ratio between the braking effort acting on the wheels and the adhesive weight varies from 80 to 90 %.

Related to the total weight of the locomotive, the braking effort is from 60 to 75 % approximately.

In the locomotives provided with compressed air brakes and pneumatic control of the electrical apparatus, the volume of free air given by the electric compressor varies from 1 500 to 3 000 litres (53 to 106 cubic feet) per minute.

Alongside of the electric compressors, the use of mechanical compressors which take their motion from the wheels is extending.

The use of these compressors increases the reliability of operation of the air service, and even allows average grades to be descended with the pantographs lowered.

### 8. Special materials.

The use of special steels in the mechanical part of the locomotive is generally limited to the gearing, the motor shafts and certain parts of the connecting rods.

Nickel steel containing from 2.5 to 5 % of nickel, or chrome-nickel steel, having a tensile strength of 70 kgr. per mm² (44.44 Engl. tons per sq. inch) at least and an elastic limit of 40 kgr. (25.39 Engl. tons per sq. inch) with 18 % elongation, is generally used for the motor shafts.

For the spur rings of the gearing, forged or cast steel of the chrome-nickel type having a minimum tensile strength of 85 kgr. (53.97 Engl. tons per sq. inch) and an elongation of 8 % is generally used, while for the pinions the tensile strength before hardening is above 100 kgr. per mm² (63.49 Engl. tons per sq. inch).

## II. — Electrical part.

### Questions concerning the electrical part of all the locomotives.

### 9. Current collectors.

The raising of the pantographs is generally brought about by the action of compressed air on the piston of a cylinder, which overcomes the action of

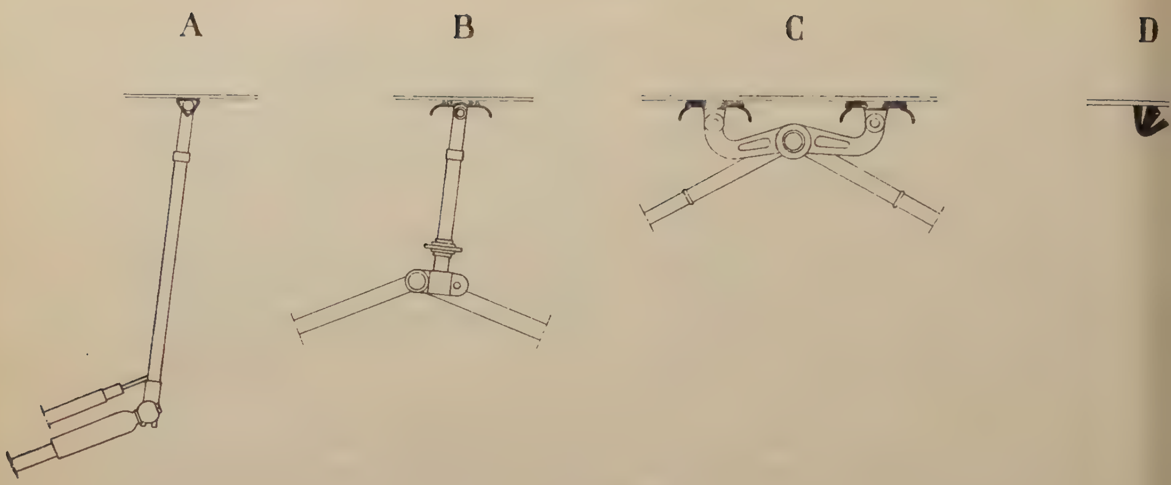



Fig. 27.

the springs for lifting. This system is preferred to the other in which the pantographs are raised with the aid of springs and are refolded by the action of compressed air, because this latter system, although permitting the pantographs to be raised without the aid of compressed air, is obviously less safe for the staff.

In figure 27, A and B, are shown the forms of the copper or brass brushes used on the pantographs of three phase locomotives.

C shows the types generally used on continuous current locomotives, and D the aluminium brushes for single phase locomotives. The pressure on the contact wire is almost proportional to the amperage of the current collected; i.e. 3.5 to 4.2 kgr. (7.72 to 9.25 lb.) for single phase 15 000-volt locomotives; 6 to 7 kgr. (13.22 to 15.43 lb) for each phase of the three-phase 3 700-volt locomotives; and 10 to 12 kgr. (22.04 to 26.45 lb.) for continuous current locomotives, 3 000 and 1 500 volts. Replacement of the brushes is carried out after running 8 500 to 20 000 km. (5 280 to 12 430 miles) according to type, atmospheric conditions and the lubrication of the brush and the wire.

### 10. Lightning arresters.

The general tendency is not to fit lightning arresters on the locomotives, with the exception of 3 000-volt continuous current locomotives, for which the electrolytic or horn types are adopted.

The windings of the transformers of single phase locomotives which have no lightning arresters are generally provided with increased insulation on about 10 % of the turns.

### 11. Switches.

On the locomotives examined there will be noted two types of switches for the traction circuit :

*a)* Switches which are closed when the locomotive is put into service, and which are opened automatically by relays when the current becomes excessive or when the voltage exceeds a maximum or minimum value;

*b)* Switches which close or open the traction circuit by the direct action of the driver.

On certain locomotives the same switch fulfils both functions.

The switches used on the locomotives of the Swiss Federal Railways, of the Swedish State Railways and other administrations are in addition provided with a special relay which, in the case of violent short-circuits, prevents the operation of the no-volt and overload current relays, thus avoiding the opening of the switches.

The short-circuit is thus maintained until the moment of opening of the nearest section switches of the contact line. The dangers of explosion of the switch opening on a short-circuit are thus avoided.

For the same reason, on certain motor-coaches of the German Railways, instead of determining the opening of the switch on a short-circuit, the line is earthed to ensure throwing out of the section switches of the line itself.

It is obvious that the devices mentioned have been adopted because of the difficulty of sufficiently dimensioning the oil switches of the locomotives, and with the object of avoiding explosions in the event of a short-circuit.

These difficulties are increased not only by reason of the greater power of the new locomotives, but above all by the fact that the remarkable extension of the electricity supply systems has increased the power of all the stations which can feed into a short-circuit.

In default of international regulations, each administration has hitherto adopted different standards for the testing of switches. However, at present, the study of these regulations has been entrusted to a Commission of the Union Internationale des Chemins de fer (U. I. C.).

Generally, the testing of switches consists of the opening of a circuit of given power, or of the interruption of repeated short-circuits, after the tripping current has been adjusted to a given value. The test from the mechanical point of view is effected by closing and opening the switch several times on no load. The voltage test is carried out, according to the administrations, at voltages which vary between 2 E + 1 000 and 2.73 E + 10 000 volts.

Opinions are divided on the use of shock resistances and explosion chambers.

The very great difference between the types employed does not permit conclusions to be drawn as to the best design of oil switches.

Nevertheless, it seems that air-break switches, being safer than the oil-break type from the point of view of safety against explosion, can also be employed on alternating current locomotives, even to fulfil the role indicated under *a*). The switches of class *b*) are generally of the dry type, even on alternating current locomotives.

On continuous current locomotives, the traction circuit is broken by means of one of the following devices :

1. Main switch which, by means of relays, opens the circuit in a very short time.

High-speed or extra high-speed circuit-breakers belong to this class.

2. The automatic opening of the traction circuit is obtained by means of the same switches as are operated by the drivers.

The opening of these switches, under the action of relays, is always preceded by the insertion in circuit of a part of the starting resistances. The intensity of the current broken is thus limited to a value fixed in advance.

### 12. Running controllers.

In single phase locomotives, three systems of running control are used : by means of electro-pneumatic contactors, drum contactors, and linear contacts.

It seems, however, premature to attempt to establish which of the systems is the best.

Amongst the locomotives for continuous current, the speed is controlled by means of electro-pneumatic contactors as a rule; only in a few cases have cam shaft controlled contactors been used.

In the single-phase continuous current locomotives, the apparatus to control the speed operates under load, while in the three-phase locomotives the controllers for the traction motors, for changing the number of poles, operate always without current and without voltage.

In single phase locomotives, the speed control apparatus serves also as step starting apparatus, while in continuous current apparatus, for the coupling of the motors in series, series-parallel and parallel, a speed controller is used, the starting regulation being effected by step-by-step switches which cut out the resistances.

In three phase locomotives, in addition to the said speed controller, there is a starting rheostat which is connected across the rotor windings.

This rheostat generally consists of a series of electrodes immersed in a chamber in which a solution of carbonate of soda can be regulated in level, up or down, by the driver.

In this way the resistance between the phases of the rotor can be varied, and with it the starting speed.

The operation of the line switches controlled by the driver is effected, when the liquid in the rheostat is completely lowered, i. e. when the rotor circuit is open. Thus the current broken does not exceed that corresponding to the magnetisation of the motors.

### 13. Transformers.

In single phase and three phase locomotives of industrial frequency oil-immersed transformers are generally employed. In the air-cooled transformers used in the locomotives of earlier construction, however, it has been observed that short-circuits between turns and to earth were more frequent.

The cooling of the oil is effected :

*a*) either by cooling tubes placed in the transformer and through which cool air is passed by a fan;

*b*) or by cooling tubes placed separately, through which passes cool air set in motion by a fan;

*c*) or by cooling tubes placed outside the locomotive, and cooled by the air current produced by running;

*d*) or by a combination of the foregoing systems.

In order to avoid explosions or accumulations of oil gas, the transformers are always provided with air vents. The limiting temperature permitted for the windings never exceeds 100° (212° F.) and that of the oil 90° (194° F.).

The Federal Railways carry out the dielectric rigidity test with triple the working voltage, in five applications each of one minute with an interval of one minute, and a test with steep-fronted waves.

### 14. Traction motors.

The number and the type of the most suitable traction motors differ according to whether single phase, three phase or continuous current locomotives are under consideration.

In high tension continuous current lo-

comotives there are, in general, four or six traction motors connected in series, series-parallel and in parallel.

It has already been remarked that for locomotives for speeds up to 90 km.-h. (55.9 miles per hour), the type of motor suspended by the nose is the most used, while for the higher speed locomotives there are employed single or double types of motor (twin motors) fixed rigidly to the locomotive frame.

The number of revolutions is generally high (600-1 100), and consequently the weight per kw. on continuous rating can be limited to about 12 to 15 kgr. (26.5 to 33 lb.); the type with four main poles and commutating poles is that generally adopted. Compensating windings are employed only in very high power motors; the armature conductors are as a rule split up into several sections in parallel to diminish the effect of a non-uniform distribution of the current.

The speed is regulated by cutting out resistances during starting, and subsequently by shunting or cutting out a certain number of turns of the exciter windings.

Lubrification is, in general, ensured by woollen pads, and the ventilation is always forced.

The most important improvements in this type of motor reside in the details of the insulation and in the more careful design of the commutation, which has permitted the adoption with safety of 3 000 volts for the contact line, generally applied to two 1 500-volt motors in series. However, the adoption of a higher limit for the contact line voltage seems to encounter difficulties arising rather from the construction of the auxiliary service apparatus than from that of the traction motors.

The single-phase motors have, in general, a speed of rotation between 400 and 1 300 r. p. m., and a nominal power between 330 and 650 kw. Examples of slow-speed motors direct-coupled to the wheels by connecting rods are not lacking, but generally the individual drive and that by gearing and connecting rods is the more widespread. It is as well however, to recall that for the trial locomotive 1 B + B 1 of high-speed type recently constructed for the German railways, motors of the type suspended by the nose have been adopted, having a continuous output of 500 kw. at 1 600 r. p. m., and a weight of 4 800 kgr. (10 582 lb.), i. e. 9.7 kgr. (21.4 lb.) per kw.

It can thus be said that amongst the single phase motors we meet with all types of design and all systems of transmission.

With the exception of the motors for the German railways, the weight per kw. of the single phase motors of less recent construction is generally 15 to 16 kgr. (33 to 35.27 lb.). In this type of motor it is, however, possible to reduce the volume of iron, and consequently the total weight, by adopting a large number of poles (12 and more).

The supply voltage for the motors is between 350 and 700 volts. The stator, which is always laminated, has generally, in addition to the series excitation winding, a compensation winding and a commutation winding.

The resistances between the rotor windings and the commutator segments are done away with in the latest designs. The number of motors used is very variable : from the single large diameter motor used on the P*a* type locomotives of the Swedish State Railways we arrive at the six twin motors (twelve armatures) which are used on the locomotives B*e* 6/8 at the Lötschberg Railways.

In the three phase 16.7-period locomotives, the traction motors ar
at the contact line voltage of 3 700.

To obtain the different speeds, the sections of the motor windings are interconnected so as to have a different number of poles, i. e. 12 and 8 or 8 and 6, or by coupling the motors in cascade.

On the locomotives of recent construc tion, with the object of limiting the use of the cascade connection, which presents the drawback of a lower power factor, a type of motor has been adopted which can run with 12, 8 and 6 poles; in this way, for the speeds of 50, 75 and 100 km.-h. (31, 46.6 and 62 miles), which are the most employed, the motors can always be connected in parallel.

It is necessary to recall that the frequency of 16.7 periods was selected at the commencement of the application of this system (1 900) solely with a view to adopting the connecting rod drive, considered at that time as the most practical, between motors and wheels.

In the industrial frequency locomotives, at 45 periods, the speeds of the motors, for a given travelling speed, is nearly three timess that of the 16-period motors, the use of the geared connecting rod system then becoming indispensable.

The supply voltage in this case is 900 to 1 300 volts. In all three phase locomotives, only two traction motors are used. The weight of the 16-period motors attains 12 kgr. (26.45 lb.) per kilowatt on continuous rating, while that of the 45-period motors is only about 7 kgr. (15.43 lb.) for motors having an output of 800 to 1 000 kw. Apart from the current system, the enclosed type motors are more numerous than the open type motors

Forced ventilation is always employed. It is necessary, however, to envisage the probable future use of auto-ventilated motors, at least for the high speed types.

The ratio between the hourly rating and the continuous rating for all types of motors is generally between 1.2 and 1.1.

It has not been possible to establish comparisons between the power of the different types of locomotives here considered; the different countries not yet having adopted uniform temperature limits for the determination of this power.

It is, in fact. known that a large number of administrations have not accepted the temperature limits proposed by the Commission Electrotechnique Internationale to define the continuous rating and the hourly rating. It has, indeed, been established that the limits proposed by the C. E. I. are too high for practical working, and lead to an unduly short life of the insulation.

On the other hand, it is generally recognised as opportune that the indications relating to the power of a locomotive shall correspond to those which can be developed practically in service, and not to a maximum conventional value which can be obtained only during a test of the motors at the manufacturer's works.

This is why the different administrations have fixed the power of the motors by adopting lower limits of temperature than those fixed by the C. E. I. In place of two different values for the limit temperature, for hourly and continuous rating, a single value has been adopted for the two. Thus, for example, on the Swiss Federal Railways, the increase of temperature of the windings must not exceed 85° (measured with thermal elements), while the Italian State Railways have adopted, to fix the power in service, the

same limits of temperature as for stationary machines.

At present a Commission of the U.I.C. is occupied in drawing up international rules to evaluate the power in service of electric locomotives.

If, on the one hand, we have been led to adopt lower temperature limits for the windings, on account of the risk of damage to the insulation, we have on the other hand recognised the necessity of improving this insulation as much as possible. This explains the fact that mica insulation is coming more into use in all the types of motors.

The test voltage generally adopted is 4 E between winding and earth, and E between two consecutive turns, E being the nominal working voltage.

### 15. Auxiliary services and drives.

In several single phase and three phase locomotives, the current for auxiliary services is supplied by a special transformer, or by tappings on the main transformer.

In continuous current locomotives up to 1 500 volts, the auxiliary service apparatus works, in general, at the same voltage as the contact line, while in the 3 000-volt locomotives one of the following systems is used :

*a*) A motor-generator set transforms from 3 000 volts to a pressure of 65 to 110 volts all the power necessary for the auxiliary apparatus (fans, compressors, accumulators, recuperation, etc.);

*b*) a motor-dynamo set serves as a voltage divider. From the middle point of the two collectors a voltage of 1 500 is derived for the compressors, fans, etc.;

*c*) a motor-dynamo set as in *a*) converts a part of the power for the accumulators, while the compressors, fans, etc.; are directly connected to the line at 3 000 volts.

The power for the air compressors varies between 7 and 25 kw., that for the fans between 7 and 30 kw. The air pressure of these fans may attain 160 mm. (6 5/16 inches) water column, and the output 400 m³ (14 126 cubic feet) per minute.

The system generally used for the control of the electric switchgear in the three phase and continuous current locomotives is the electro-pneumatic system.

In any case, the superiority of the latter is generally confirmed.

### 16. Safety of personnel.

The dangers to which the personnel of electric locomotives is exposed are of two kinds: those deriving from accidental contact with the high tension conductors, and those caused by the explosion of or fire in the apparatus containing oil (transformers and switches).

Amongst the apparatus, the current collecting gear is the most dangerous, if its overhaul is not carried out with the observation of the necessary precautions.

In all the Companies dealt with in this report, the overhaul of the collectors is only carried out after the contact line has been earthed.

The safety of this operation, if it is executed at the depot, is generally ensured by a block key, which, being in the hands of the workman carrying out the overhaul, gives him the assurance that the line is earthed and that the switch cannot be closed.

It has been thought necessary in certain cases that the same workman who is carrying out the overhaul shall earth the contact line in a very evident manner, in the proximity of the locomotive.

On the contrary, when it is necessary

to look after the collecter contacts outside of the depot, it is generally an instruction to the staff to require that the line should be relieved of tension and earthed, and to have confirmation of this by the usual means. But as this confirmation usually involves loss of time, sometimes fairly considerable, the staff is sometimes induced to neglect the necessary precautions.

Foreseeing this, some administrations have ordered that no repairs may be carried out to the current collectors while out on the track, and that the staff must confine itself to lowering and isolating electrically the damaged collector, continuing to run with the other.

In this regard the Italian State Railways have ordered, for continuous current locomotives, that only one collector may be raised at a time, so as to leave one in reserve.

However, to take account of cases in which the personnel might come into contact with collectors outside the depot, even in defiance of regulations, additional arrangements have been made to reduce the probability of danger.

The three phase collectors of the Italian State Railways have the brushes interconnected mechanically so that raising and lowering cannot take place at the same time.

There is also being studied a device intended to earth the pantographs automatically immediately they are lowered.

To provide for the possibility of one operator raising the collectors accidentally while another operator is on the roof, there has been placed alongside the ladder leading to the roof a tap which puts the compressed air pipe for the lifting in communication with the atmosphere.

On the Swiss Federal Railways, the current collectors are interlocked with the ladder leading to the roof in such a way that the bows are lowered automatically as soon as the ladder is in position for ascending to the roof, upon which a warning signal sounds.

In certain administrations, a type of current collector is used, which, contrarily to that already described, is lifted by the action of springs and is reclosed by compressed air.

A special locking device controlled by hand maintains the pantograph in its lowered position. This system has one advantage: if there is no air at a sufficient pressure the pantograph can still be raised. But on the contrary there is the risk of putting the locomotive under voltage if from any cause the locking device is open.

Access to the high tension compartments, which contain the electric switchgear, is generally prevented by lock and key, the key being interconnected with the lifting tap for the current collectors, so that the key itself can only be liberated for the opening when the pantographs are lowered. Conversely, when the tap is in the lifting position, the key cannot be liberated. It is only after having put the key in place that the lifting position can be obtained. Finally, the key cannot be removed from the lock of the high tension compartment if the doors are not shut.

On some locomotives this interlock has been completed by connecting the opening of the high tension cabin with the earthing of the current collectors.

In this manner the possibility has been obviated of contact being made with the high tension as a consequence of a hasty manipulation of the block key while the trolley is still under tension.

With regard to defence against explo-

sions or fire in oil-containing apparatus, the Swiss Federal Railways have adopted an explosion valve for the switches and have provided them with a relay, already mentioned, which prevents opening in case of violent short-circuits. The transformers are provided with breather tubes preventing the accumulation of gas.

On the latest locomotives of the Italian State Railways, the switches are placed in the forepart of the body, that is, well away from the personnel, or enclosed in sheet steel cabins. The switches and transformers are provided with breather tubes.

The locomotives have generally been equipped with liquid fire extinguishers of a kind which will not damage the insulation and which develop inert gases. It has sometimes been remarked, however, that these gases may be dangerous to the staff.

### III. — Questions peculiar to high speed locomotives.

The question of locomotives for high speed, i. e. above 75 km. (46.6 miles) per hour, was dealt with at the last Congress in London.

The conclusion was arrived at there that in view of the great variety of types, even for locomotives of one system, it was premature to draw conclusions as to the types considered most satisfactory.

To arrive at a more precise conclusion, I think it well to distinguish locomotives which can run at speeds above 100 km. (62 miles) per hour from those for which this speed is to be considered as a maximum.

Amongst the former class we find the following locomotives:

1. Single phase locomotives A 4/7 of the Swiss Federal Railways (diagram 1 $D_0 2$—B.B. transmission system [fig. 28]) (1);

2. 1 500-volt continuous current locomotives, type 7200, of the North of Spain Railways (diagram $2C_0 + C_0 2$, — B.B. transmission system [fig. 29]);

3. 3 000-volt continuous current locomotives, type E 326 of the Italian State Railways (diagram 2C2 [fig. 30]), hollow shaft transmission system, plate spring.

These three types present the following characteristics in common:

1. Individual drive of the axles by gearing and motors raised above the chassis;

2. Leading bissel truck (except locomotive 1 $D_0 2$ of the Swiss Federal Railways);

3. Double cab for the driver, a high tension compartment in the middle, and two bonnets at the ends.

The three locomotives, although having nearly the same power, have a different wheel arrangement, which depends obviously on the maximum weight per axle (19.2, 16 and 21 t.) (18.90, 15.74 and 20.67 Engl. tons) permitted on the rails.

Although it is impossible to exclude the use of other transmission systems for very high speed locomotives, it is to be noted nevertheless that the geared connecting rod system and the connecting rod system are employed solely for locomotives for the maximum speed of 100 km. (62 miles) per hour. The use of connecting rods entails the necessity of counterweights on the wheels and on the motors shafts. It is recognised that even if these counterweights are calculated

(1) *Note.* — These locomotives are not intended to exceed in ordinary service the speed of 100 km. (62 miles) per hour, but in consideration of the good results obtained during the tests they may be classed amongst the very high speed locomotives.

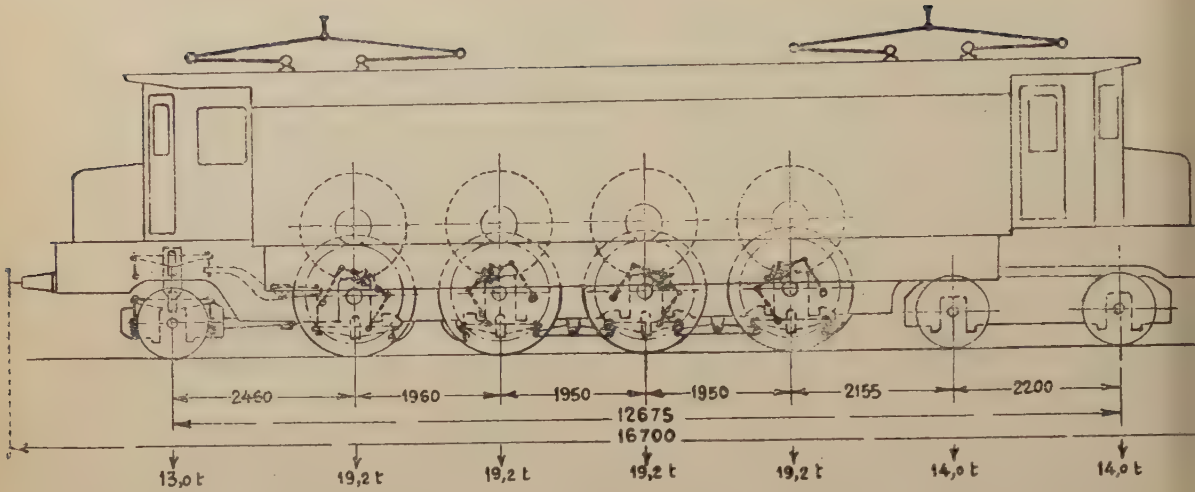



Fig. 28.

with care it is very difficult to avoid disturbing movements at the higher speeds.

Amongst the very high speed locomotives here considered, we do not find any with the motors suspended by the nose. It is well, however, to remember that this arrangement has been adopted on the trial locomotives $1B_0 + B_01$ of the German railways, which have to attain the speed of 110 km. (68.4 miles).

If we now take into consideration the whole of the locomotives for which 100 km. (62 miles) per hour is to be considered as the maximum speed, we note that: all transmission systems are employed; the arrangements of the wheels, frame and cab are very different amongst them. It is therefore impossible, for this category of locomotives, to discover common tendencies for all the systems of current.

If, on the contrary, the locomotives of this class are grouped according to the current system, the following tendencies might be put on record:

a) *For the continuous current locomotives.*— The direct transmission system with gearing and motors suspended by the nose, articulated trucks with leading axles or motor bogies without leading axles (diagram $1\,C_0 + C_01$, locomotives of the North of Spain [fig. 31], $B_0$ - $B_0$, locomotives of the North of Milan [fig. 32], $B_0 + B_0 + B_0$, locomotives E 625 of the Italian State Railways [fig. 33]) are the most employed;

b) *Three phase, 16.7-period locomotives.* — Connecting rod drive; for 45-period locomotives, drive through gearing and connecting rods.

In the two types there is always the single frame and one of the arrangements: 1 C 1, 2 C 2, 1 D 1 (figs. 34, 35, 36 and 37).

c) *Single phase locomotives.* — In this category a greater variety is to be remarked, both in the drive (individual geared drive, geared connecting rod and direct connecting rod drives) and in the arrangement of frame and wheels. Individual geared axle drive is used on almost the whole of the locomotives A*e* 3/5 and A*e*

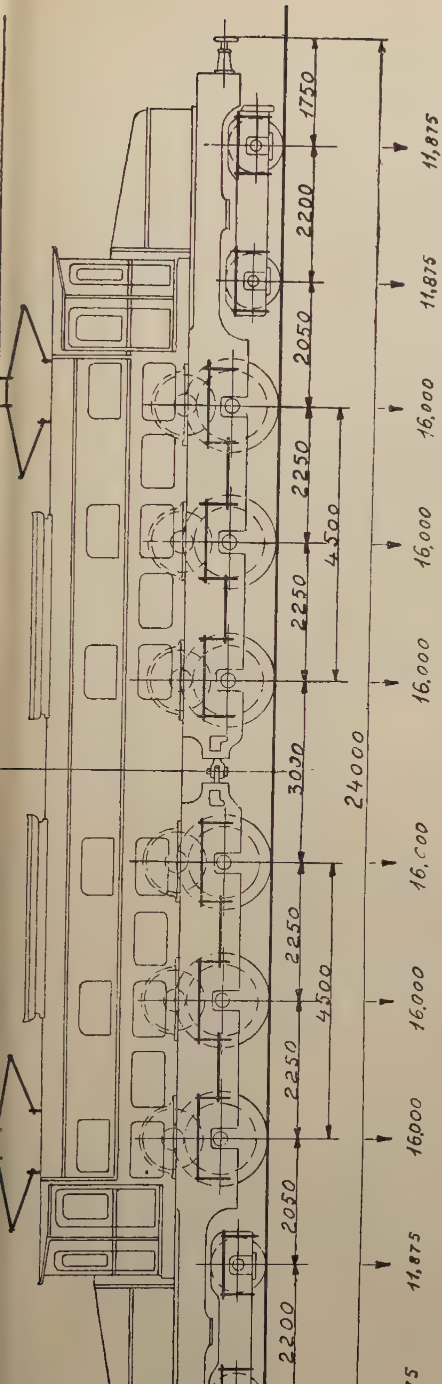

1750
2200
2050
2250
2250
3000
2250
2250
2050
2200
1750
4500
4500
24000
11,875
11,875
16,000
16,000
16,000
16,000
16,000
16,000
11,875
11,875

Fig. 29.

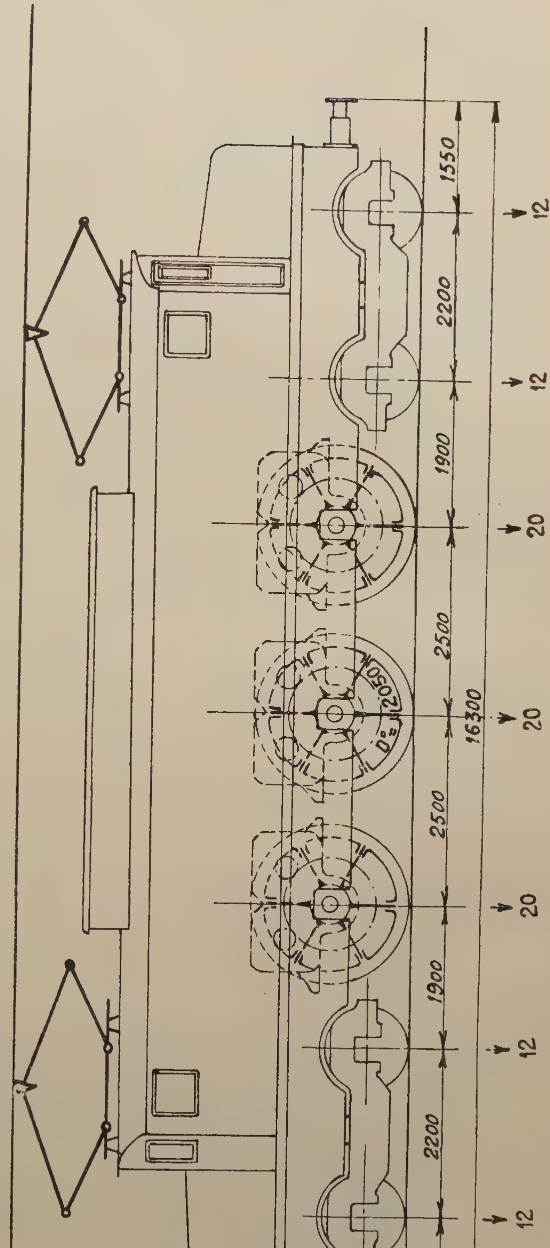

1550
2200
1900
2500
2500
1900
2200
1550
16300
D = 2050
12
12
20
20
20
12
12

Fig. 30.

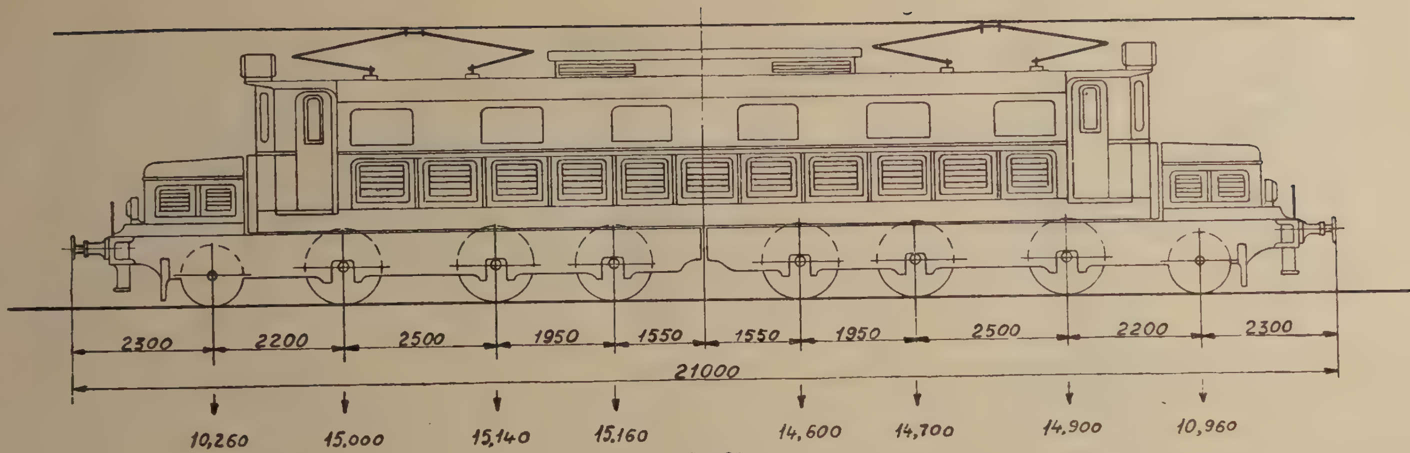
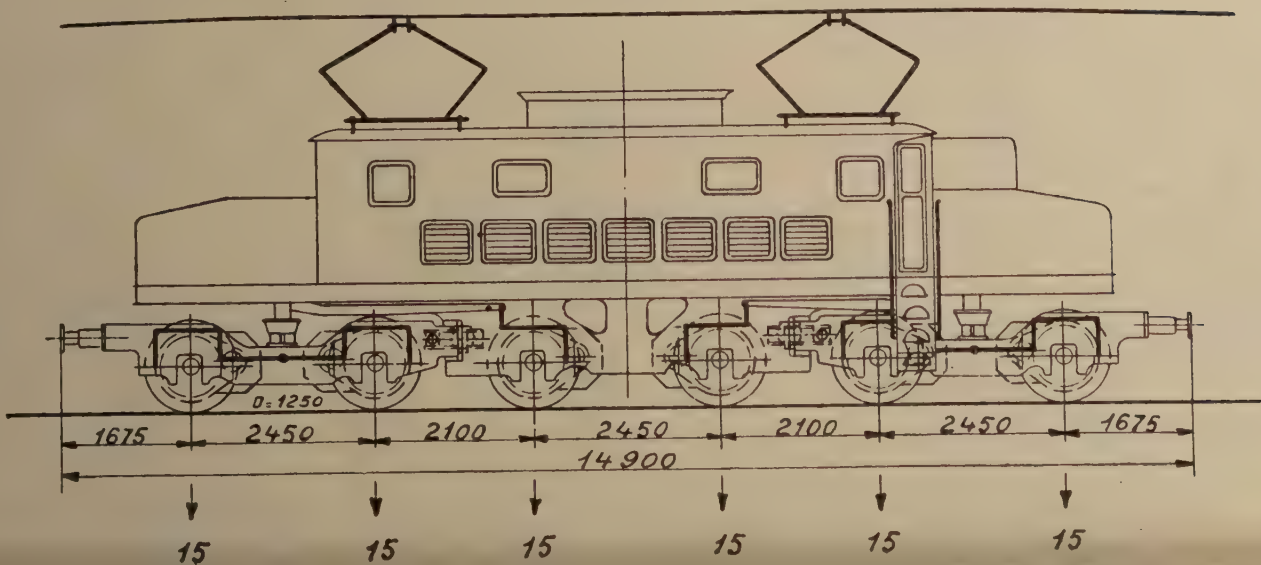

2300
2200
2500
1950
1550
1550
1950
2500
2200
2300
21000
10,260
15,000
15,140
15.160
14,600
14,700
14,900
10,960

Fig. 31.


D=1250
1675
2450
2100
2450
2100
2450
1675
14900
15
15
15
15
15
15

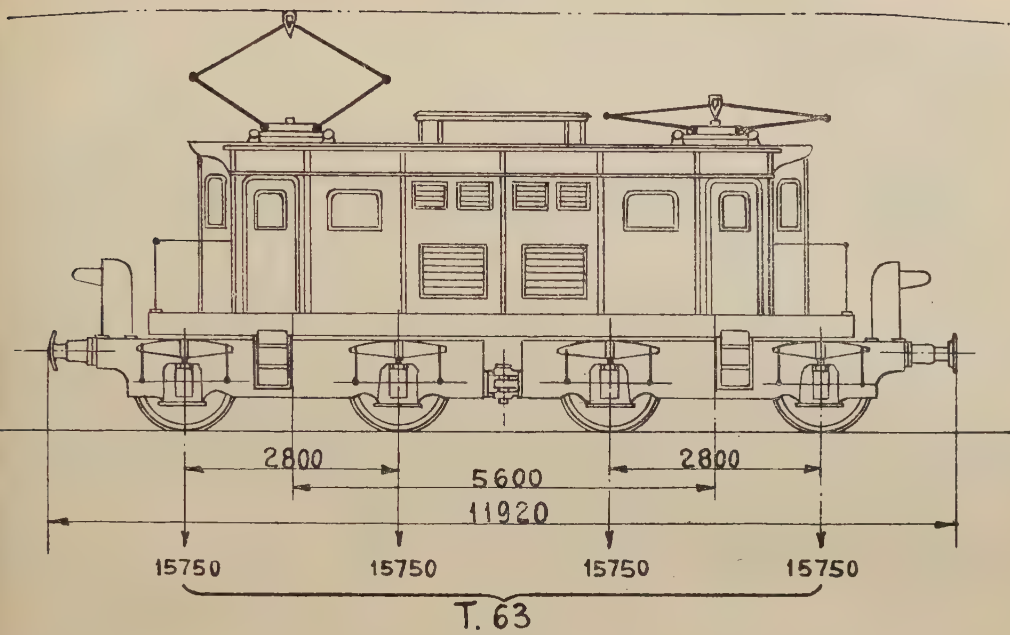

2800
2800
5600
11920
15750
15750
15750
15750
T. 63

Fig. 32.

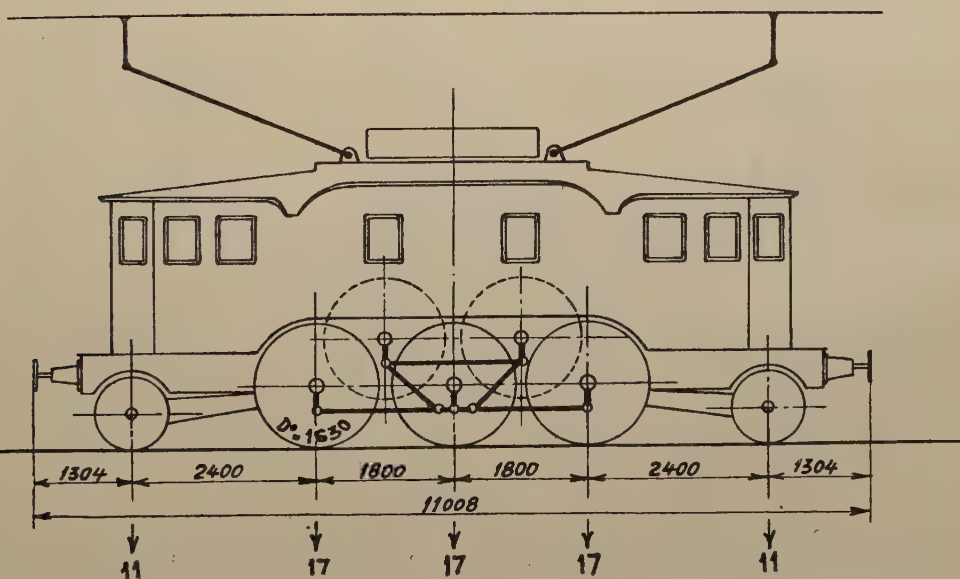

D=1630
1304
2400
1800
1800
2400
1304
11008
11
17
17
17
11

Fig. 34.

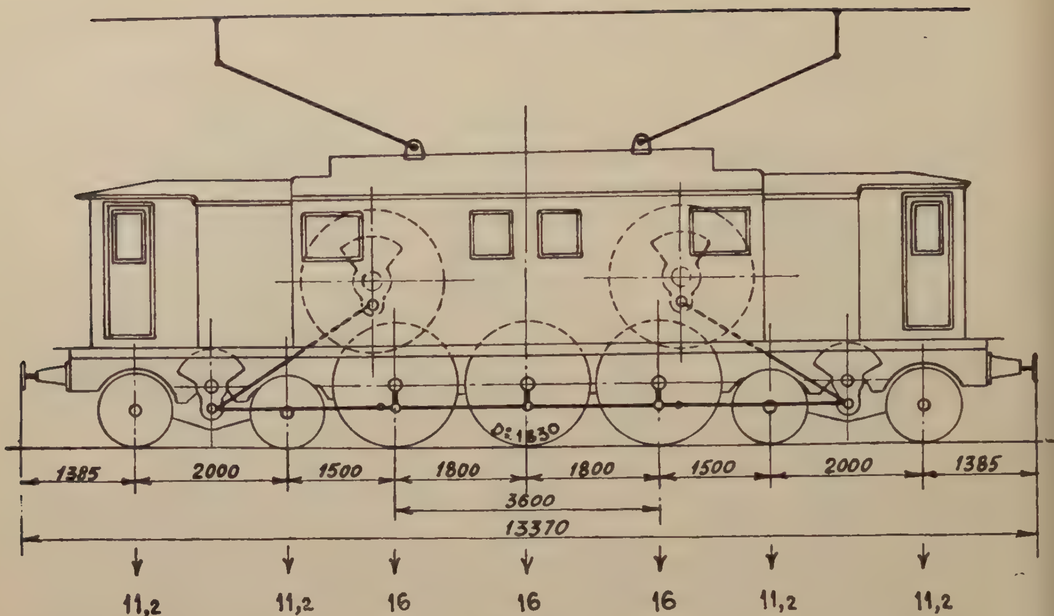



Fig. 35.

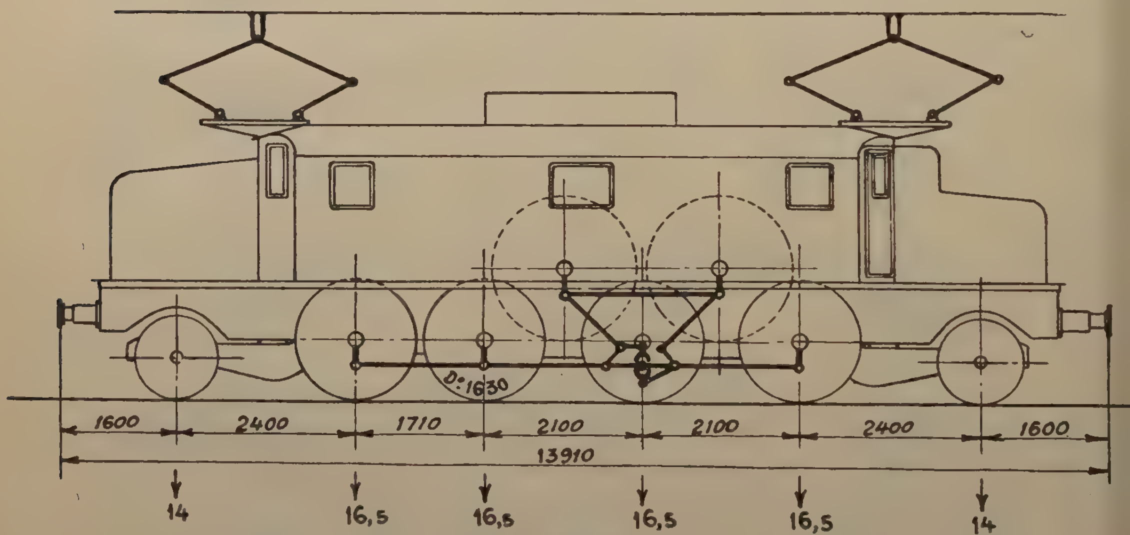



Fig. 36.

3/6 of the Swiss Federal Railways (figs. 38, 39), and on the locomotives B*e* 6/8 of the Bernese Alps Railways (fig. 40).

The geared connecting rod drive has been adopted for the locomotives A*e* 3/6 and B 5/7 of the Swiss Railways (figs.

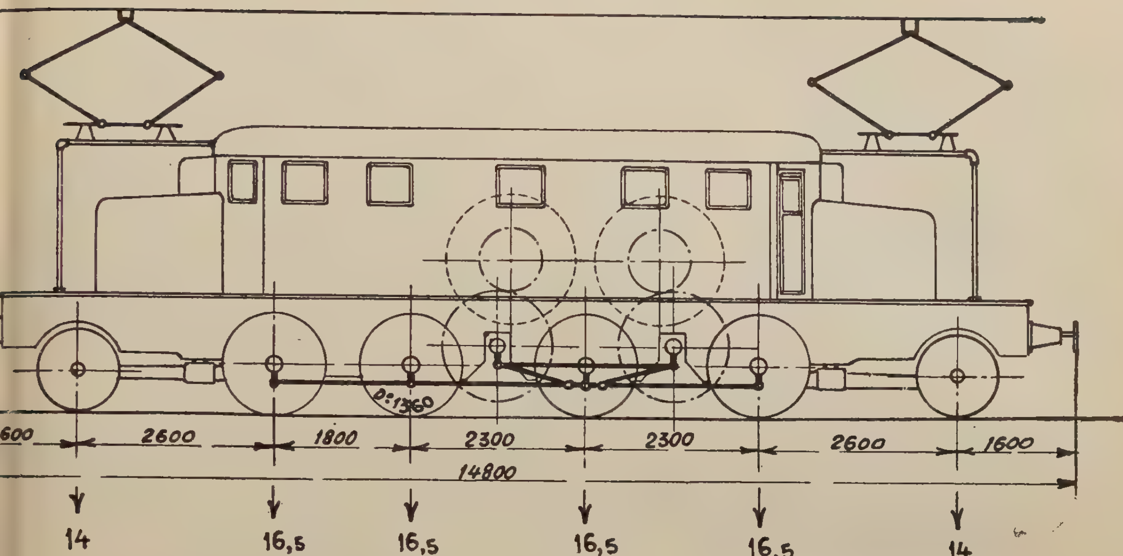



Fig. 37.

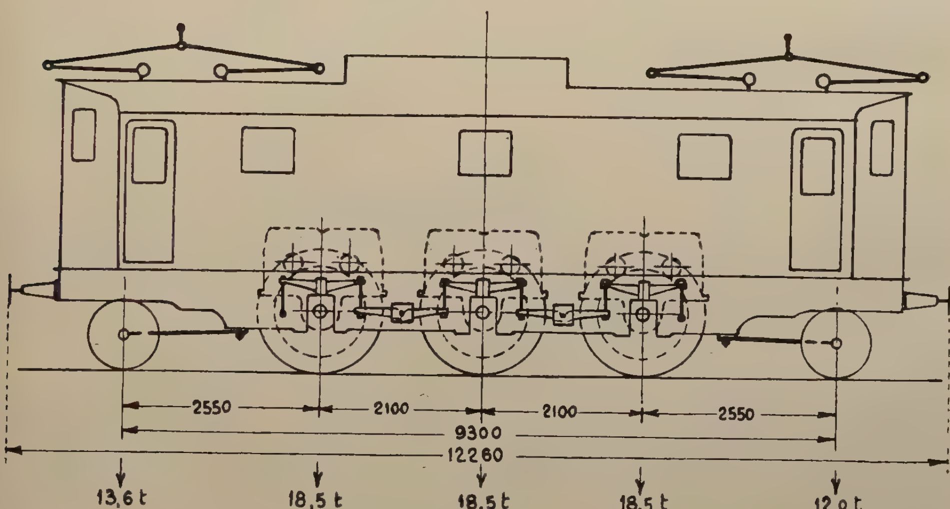



Fig. 38.

41, 42) and on the types D an P$b$ of the Swedish State Railways (figs. 43, 44).

The drive by connecting rods and jack shaft is used on the locomotives types P$a$ (fig. 45) of the Swedish State Railways.

It appears, however, that, taking account of the tendency to adopt high-speed single-phase motors, the type of locomo-

tive with gear, or gear and connecting rod drive, will be the most widely utilised.

## IV. — Questions peculiar to goods and mountain locomotives.

Amongst this class of locomotive, for a given power, a higher adhesive weight has been adopted than in the other classes. The types with six driving axles are therefore the most widely used amongst the single phase locomotives 1 C + C 1 of the Swiss Federal Railways (figs. 46, 47) and of the Swedish and Norwegian State Railways (figs. 48, 49) and the continuous current locomotives $C_0$—$C_0$ and $C_0 + C_0$ of the North of Spain Railways (figs. 50 and 51) and $B_0 + B_0 + B_0$ of the Italian State Railways (fig. 33). For the three-phase, the type *o*E*o* is exclusively adopted (figs. 52, 53).

The collective drive by gears and connecting rods, which is indicated for the locomotives with two motors and several axles, is often applied to single phase locomotives of this class, while for three phase locomotives the use of connecting rods is general. For continuous current locomotives, the type of motors suspended by the nose is generally employed. It should, however, be recalled that in certain continuous current, narrow gauge, high power locomotives, not considered in this report, the geared connecting rod system has been adopted.

As the speed of locomotives of this class does not exceed 60 km. (37.3 miles), total adhesion types have often been adopted.

On the Federal Railways goods locomotives alone are designed for regeneration.

For reasons of safety, the locomotive is not braked electrically as long as the train is braked by hand. The electric braking only operates, for the moment, when running light. The brake gear is so designed that in addition to the weight of the locomotive a small part of the weight of the train can also be braked.

Taking into account, in the case of regeneration, an average efficiency of 45 to 55 % and a cos $\varphi$ of 0.3 to 0.5, the current gained practically does not enter into consideration. The maximum speed tolerated rises, in the case of light running with regeneration on grades of 27 $^{00}/_{00}$ (1 in 37) to 65 km. (40.4 miles) per hour.

The locomotives of the Bernese Alps Railways are not fitted with regeneration; the locomotives B*e* 6/8 are provided with electric braking on resistances, dimensioned to brake the locomotive alone up to 65 km. (40.4 miles) per hour.

In continuous current locomotives regeneration is effected by exciting the motors from an independent source of power. In this case, the power and the speed are influenced not only by the action of the driver, but also by the variations of voltage of the contact line.

More or less complicated devices are adopted for the regulation of the power regenerated. The total regeneration of power supplied by the train is, however, currently practised on the locomotives of the North of Spain Railways and of the Italian State Railways.

On grades between 20 and 30 $^{00}/_{00}$ (1 in 50 and 1 in 33), the kw.-h. regenerated are between 20 and 30 % of those absorbed by the trains of the same weight ascending.

In three phase locomotives, regeneration is effected at constant speed without the locomotives having special devices and without regulating action by the driver.

On grades of 25 $^{00}/_{00}$ (1 in 40) the num-

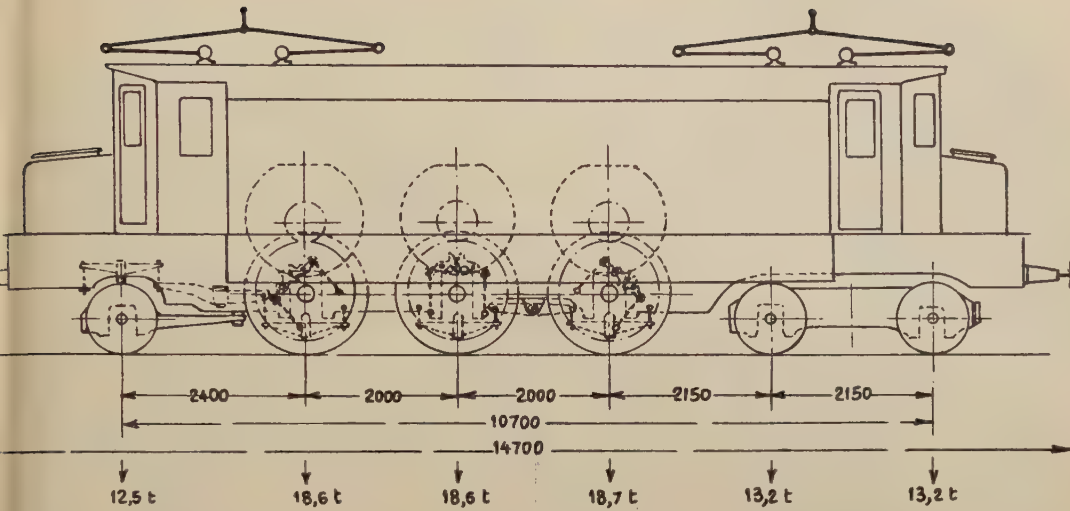



Fig. 39.

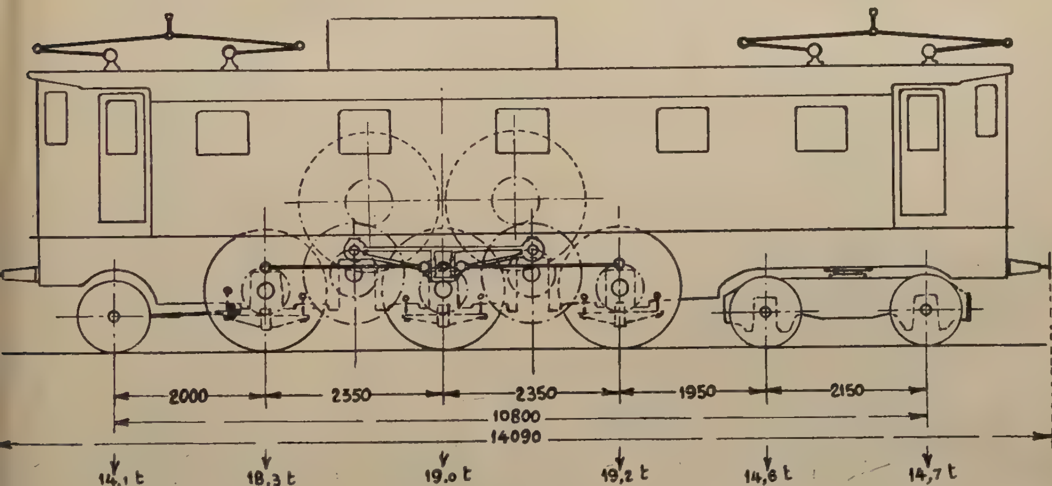
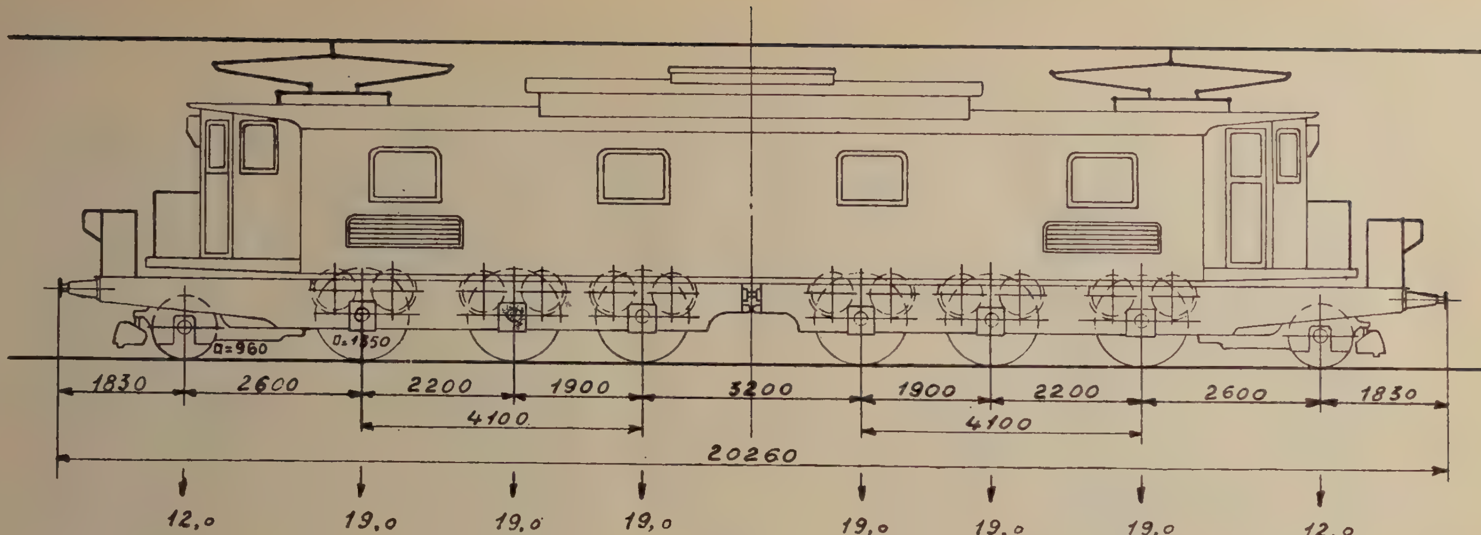



Fig. 41.

ber of kw.-h. regenerated amounts to as much as 30 % of those absorbed by the ascending trains.

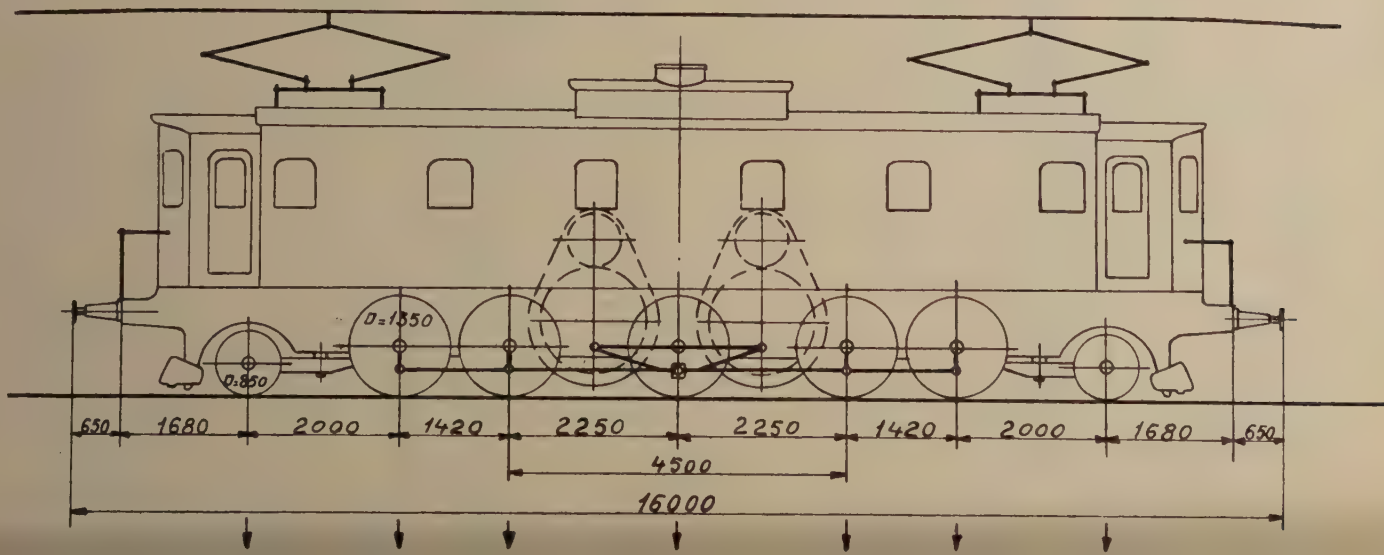
The Italian State Railways instruct their staff to effect regeneration in order to obtain safer braking, it being possible during regeneration to feed the brake piping and to maintain the maximum pressure in the auxiliary reservoirs.

Thus one has always available the entire power of the brakes. A meter measures the energy recuperated, which



D=960
D=1350
1830
2600
2200
1900
3200
1900
2200
2600
1830
4100
4100
20260
12,0
19,0
19,0
19,0
19,0
19,0
19,0
12,0


Fig. 40.



D=1350
D=850
650
1680
2000
1420
2250
2250
1420
2000
1680
650
4500
16000

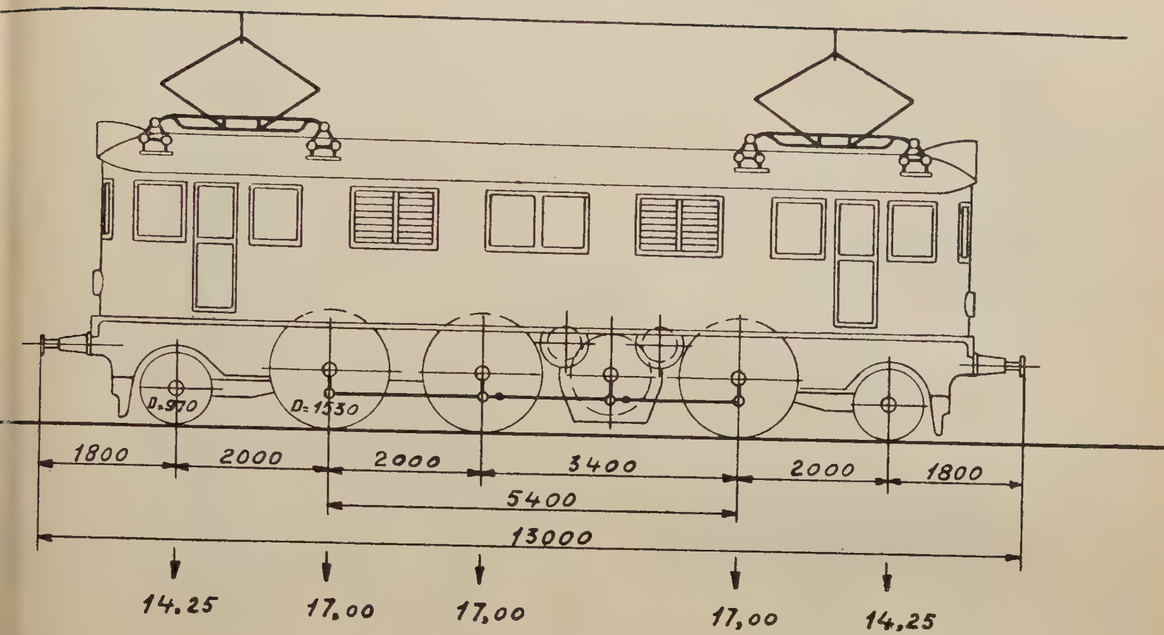

D=970
D=1530
1800
2000
2000
3400
2000
1800
5400
13000
14.25
17.00
17,00
17,00
14,25

Fig. 43.

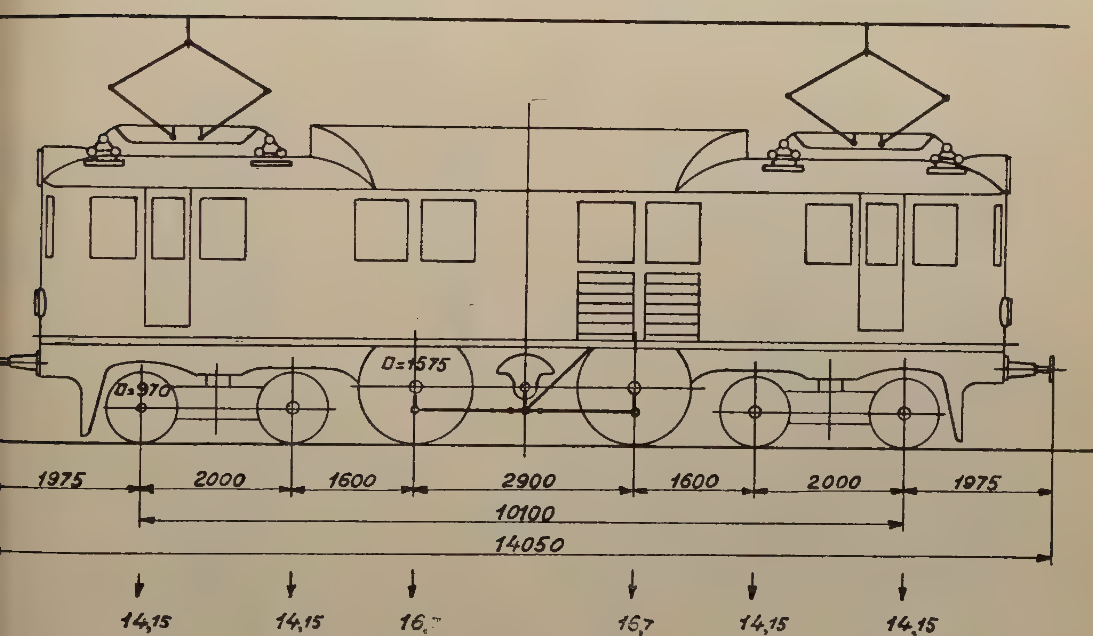
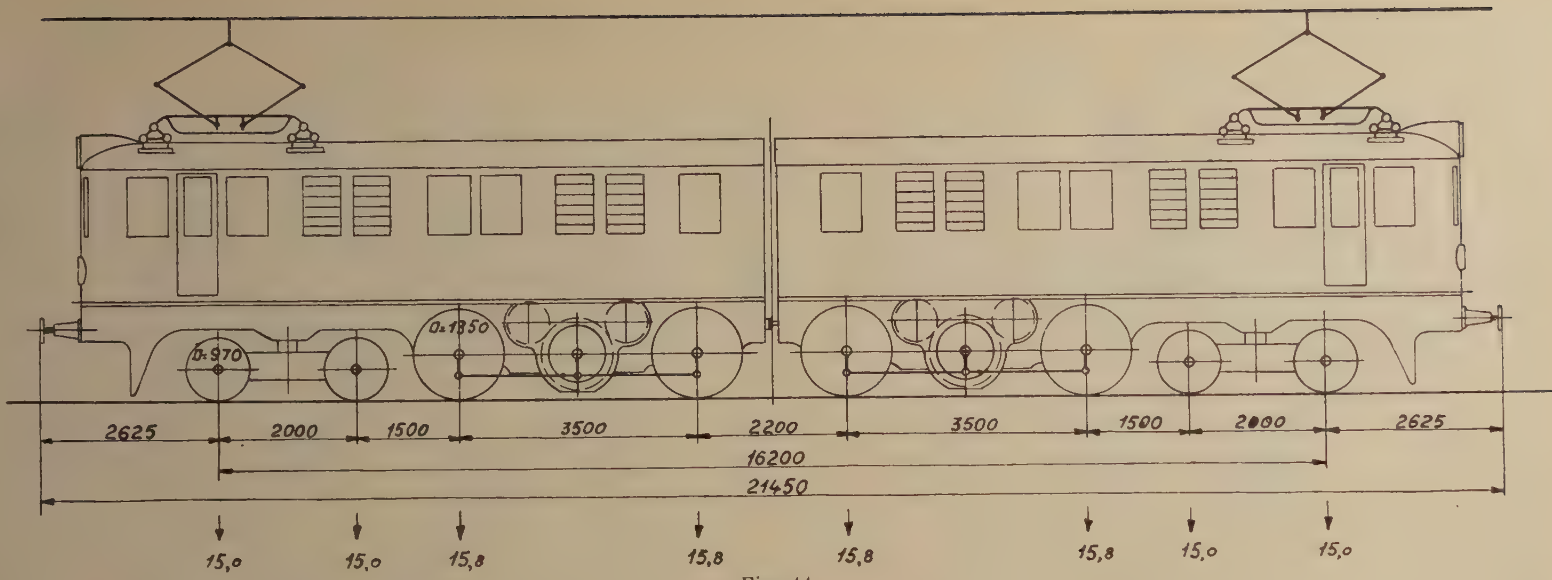
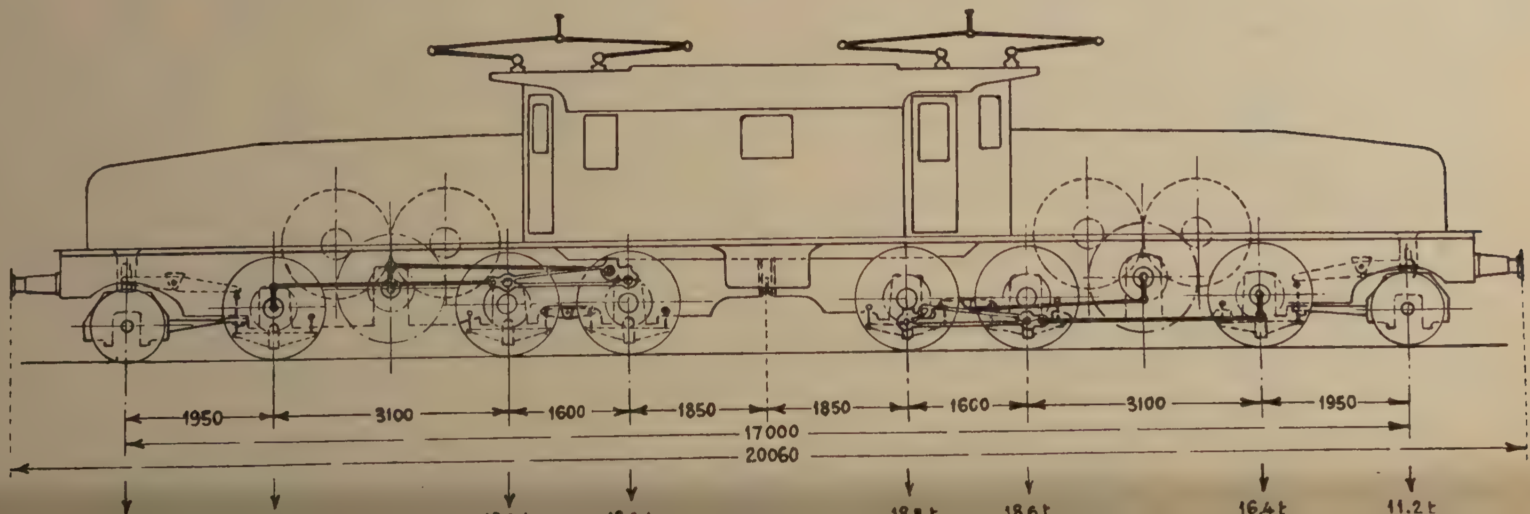

D=970
D=1575
1975
2000
1600
2900
1600
2000
1975
10100
14050
14,15
14,15
16,7
14,15
14,15

Fig. 45.



D=970
D=1850
2625
2000
1500
3500
2200
3500
1500
2000
2625
16200
21450
15,0
15,0
15,8
15,8
15,8
15,8
15,0
15,0


Fig. 44.



1950
3100
1600
1850
1850
1600
3100
1950
17000
20060
16,4 t
11,2 t

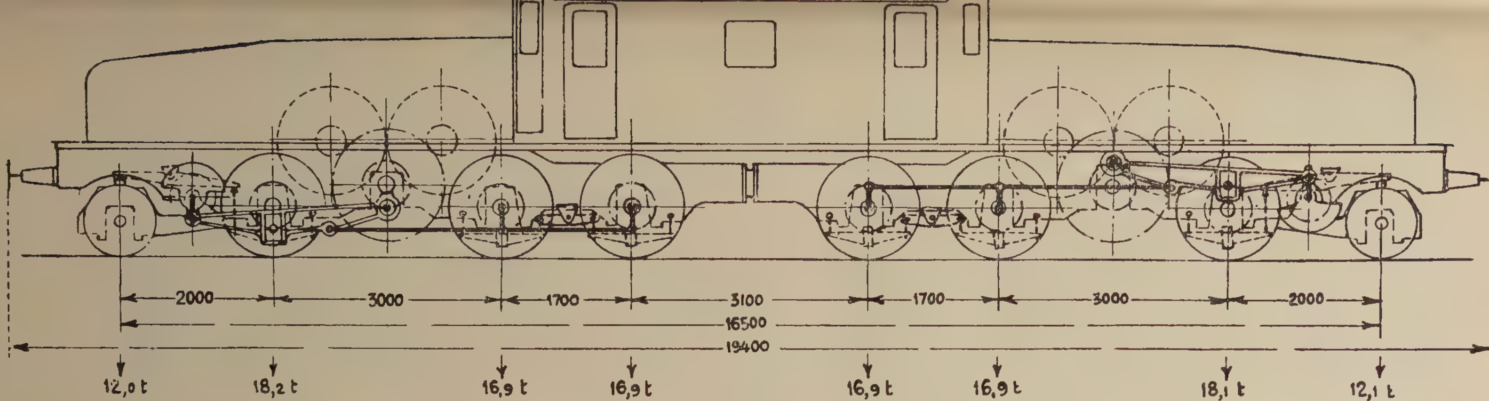

2000
3000
1700
3100
1700
3000
2000
16500
19400
12,0 t
18,2 t
16,9 t
16,9 t
16,9 t
16,9 t
18,1 t
12,1 t

Fig. 47.

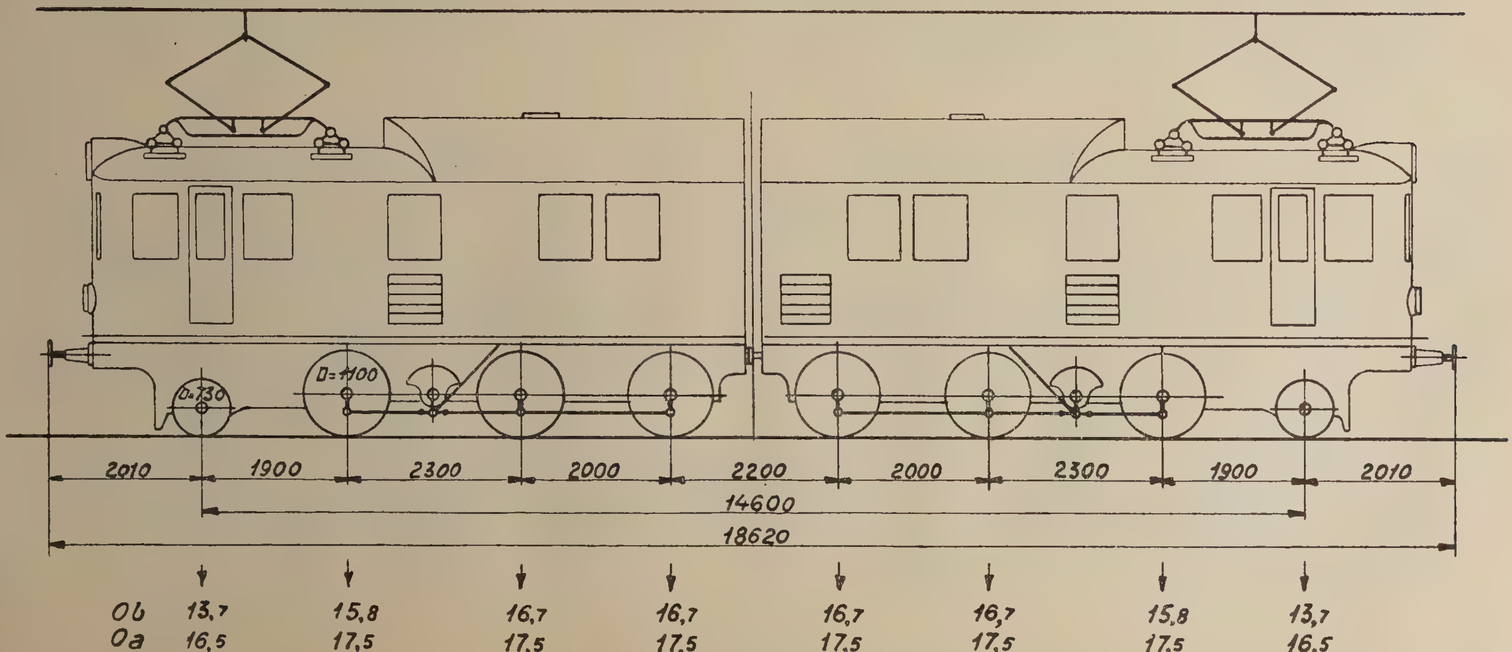

D=730
D=1100
2010
1900
2300
2000
2200
2000
2300
1900
2010
14600
18620
Ob 13,7 15,8 16,7 16,7 16,7 16,7 15,8 13,7
Oa 16,5 17,5 17,5 17,5 17,5 17,5 17,5 16,5

Fig. 48.

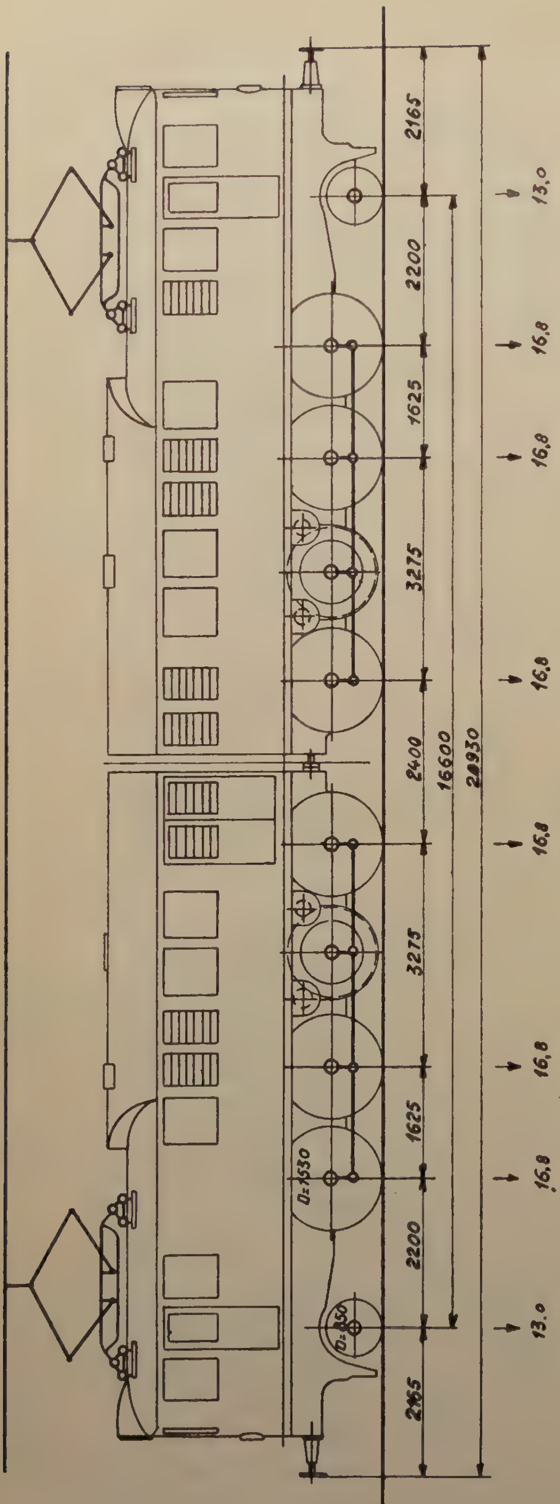



Fig. 49.

is checked by the depot chief. A special premium is granted for this energy recovered.

For trains not fitted with the automatic brake, the speed of descent is limited to 25 km. (16.5 miles) per hour to facilitate the stoppage of the train if the voltage happens to fail.

In this eventuality, the buffers of the cars which are compressed against the locomotive during regeneration are suddenly released, and occasionaly sometimes the draw gear is broken. To prevent this danger, the air brakes are lightly applied on the locomotive alone during regeneration.

The use of double and triple heading, with double heading and with a locomotive at each end, is fairly common, particularly for goods service, with all systems of locomotives.

The Swiss Federal Railways have found that in their goods trains it is preferable to place the assiting locomotive in such a way that the pull on the drawbar of this shall attain the maximum admissible for the grade to be run over.

This arrangement has shown itself to be much safer than when working with the auxiliary locomotive in the rear.

The Bernese Alps Railways used double heading with the banking locomotive at the front or at the rear, but with the latest powerful locomotives double heading is not provided for.

On the Italian State Railways double heading is generally carried out by placing the locomotives one at the front and the other at the rear. Signals between the locomotives are made by whistle.

With the object of reducing the probability of breaking the drawgear, trials with double and triple heading have been carried out by placing one locomotive in

the middle or at one-third distance from the head of the train.

This system presents as its only disadvantage the necessity of shunting the train at the beginning and end of the grade.

The general tendency is not to effect double heading with one locomotive in front and one behind, but it is evident that, to arrive at this, it is necessary for the maximum admissible load for the drawgear to be higher than it is at present.

## V. — Operation.

The data which have been collected as regards operation not being complete and uniform, it has not been possible to arrive at general conclusions.

The proportion of locomotives out of service, on account of repairs in the shops, is between 11 and 25 %; that of the locomotives under repair in the shops and under overhaul in the depots varies between 15 and 27 %.

It is evident that the figures depend on the type of locomotive and the arrangements adopted for repair.

Two main repair systems are generally followed:

1. A general overhaul, executed when the necessity presents itself of replacing or repairing (in particular) the details of the mechanical portion: turning of the wheel tyres, of the bearings, making good the pivots, repairs to frame, riveting etc.

These overhauls have to be made after 200 000 or 300 000 km. (124 000 to 186 000 miles), approximately i. e. after two or three years' service.

Between two such repairs, less important overhauls are in general carried out to the mechanical and electrical parts,

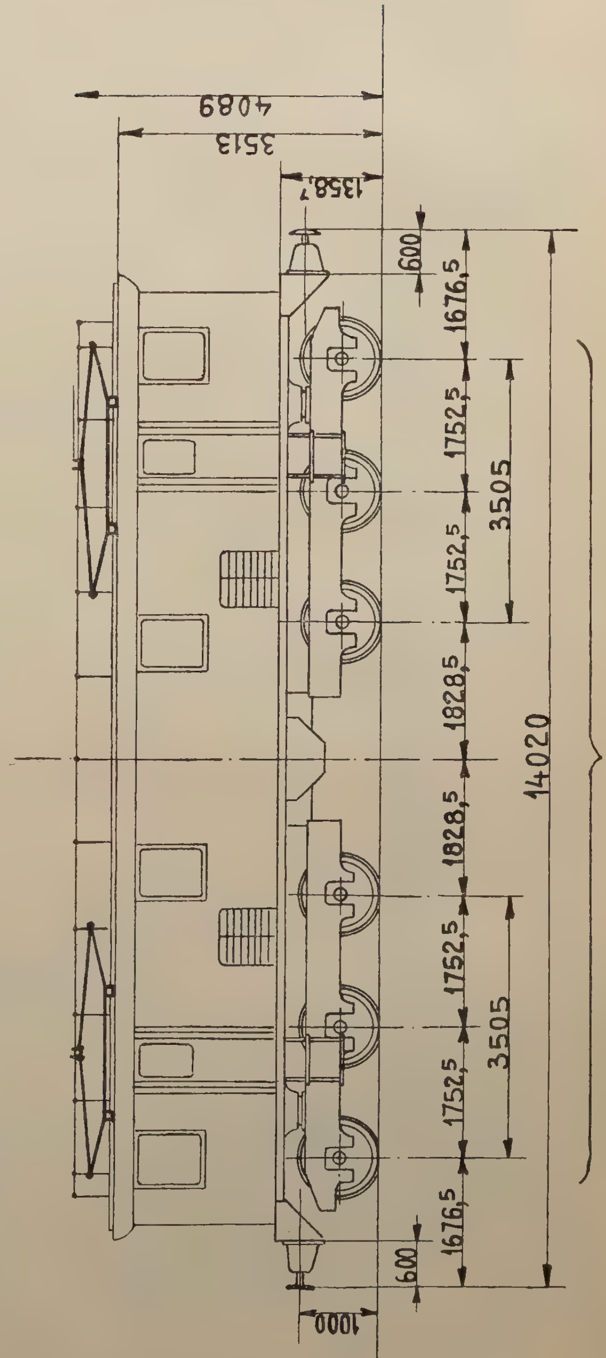



Fig. 50.

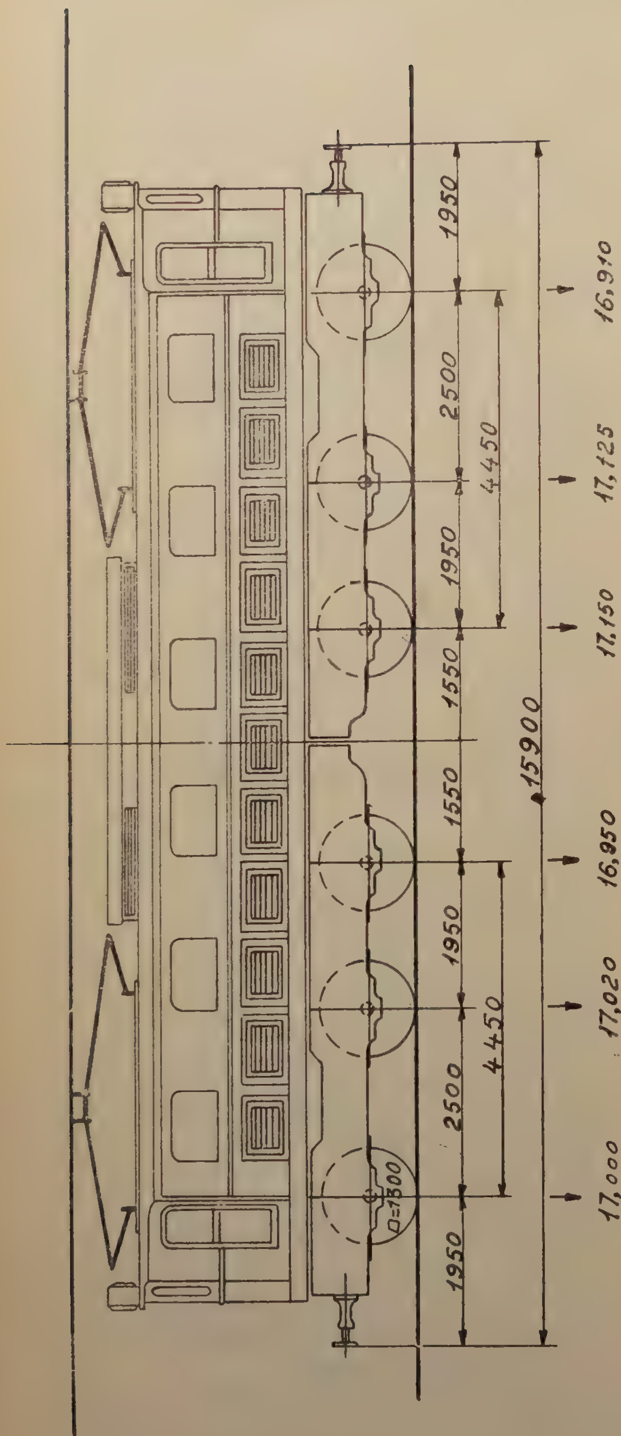


Fig. 51.

every month, or every three or six months;

2. More frequent general overhaul — every 100 000 km. (62 000 miles).

Between two of these repairs there are carried out, during the turn of service of the locomotive, less important overhauls effected in the depot every ten or fifteen days.

*Kilometres travelled (mileage run) between two repairs.*

The figures communicated in this respect are very variable, mainly on account of the different systems of repair. It may, however, be affirmed, taking into consideration locomotives of different types of the same administration, that connecting rod locomotives and those for goods service have to be more frequently repaired to take up the play of the shafts, connecting rods and cranks.

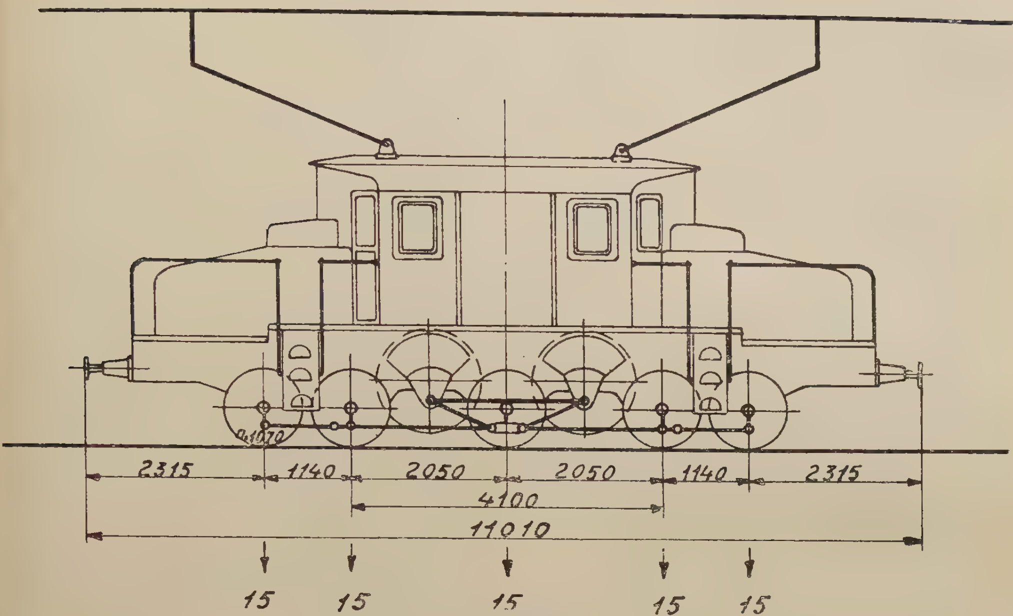
In this regard, the necessity for repair depending mainly on the mechanical parts, the advisability has been recognised of dimensioning the mechanical organs of the electric locomotives more amply than those of steam locomotives.

In any case, it has been verified that the average mileage between two overhauls of the electric locomotive is 50 % at least higher than that of the steam locomotive.

*Annual mileage.*

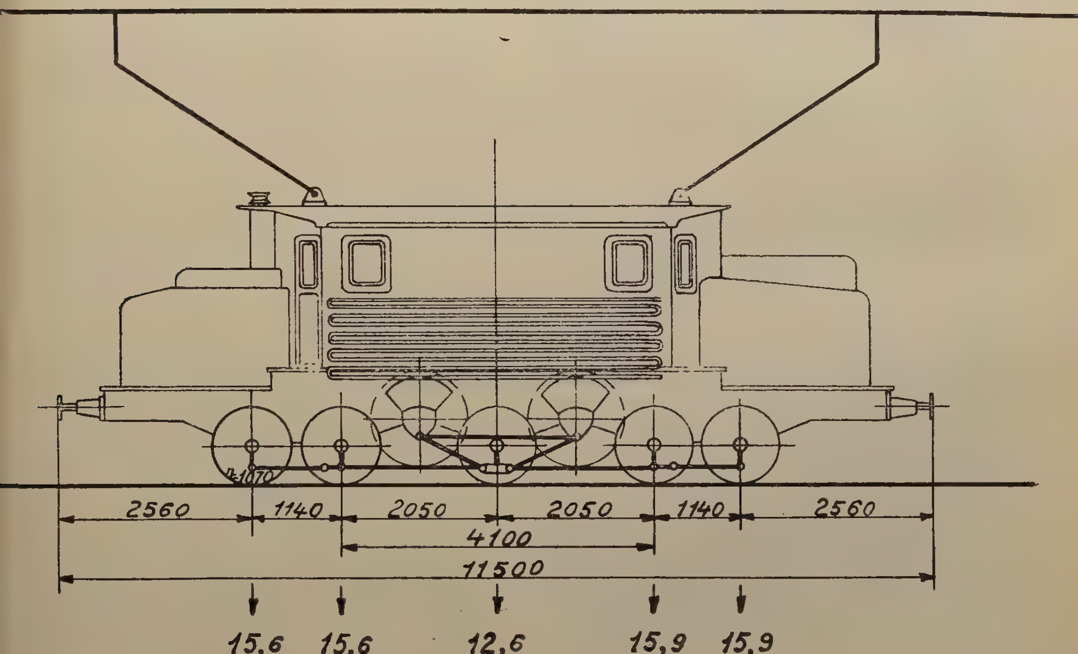
The annual mileages effected by the different types of locomotive do not vary much one from another.

The annual distance run by the 3 000-volt mountain service locomotives of the North of Spain Railways is on the average 54 000 km. (33 550 miles). On the Swiss Federal Railways it is 72 300 (44 900 miles) for passenger locomotives and from 76 000 to 78 000 for goods lo-



D.1070
2315
1140
2050
2050
1140
2315
4100
11010
15
15
15
15
15


Fig. 52.



D.1070
2560
1140
2050
2050
1140
2560
4100
11500
15,6
15,6
12,6
15,9
15,9


Fig. 53.

comotives (47 200 to 48 500 miles) while the B*e* 6/8 locomotives of the Bernese Alps Railways accomplish 94 000 km. (58 400 miles).

For the Italian State Railways, the three phase and continuous current locomotives for goods and mountain services accomplish on the average 60 000 km. (37 300 miles), those for passengers on the plains run 90 000 to 100 000 km. (55 900 to 62 000 miles).

It is evident that the mileage is influenced not only by the type of locomotive, but also by the kind of service, the time tables, the length of line electrified, etc., and for this reason the above data are not mutually comparable.

*Statistics of accidents in service.*

To the questionnaire sent to the administrations, a prospectus was attached relating to the percentage of accidents occurring in the mechanical and electrical parts, considering an accident as such if it has caused a delay to the train of at least ten minutes, or a repair in the shops.

Although all the administrations have statistics of accidents, as these are made up on different methods, complete conclusions could not be drawn in this respect. It would, however, have been interesting to be able to compile, with the aid of these statistics, a list showing which are the parts of the locomotive which are the most easily damaged, and consequently most susceptible of improvement.

According to the statistics of the Swiss Federal Railways (single phase locomotives), although the proportion of accidents to the electrical part (55 to 65 %) is higher than that of accidents to the mechanical part (45 to 35 %), they have less serious consequences than the latter.

Of 100 accidents there are 50 which do not affect the running of the train, but only necessitate repairs at the depot; 21 others cause delays up to ten minutes, the remaining 29 causing delays of more than ten minutes. The latter are found in connection with mileage figures exceeding 40 000 km. (24 850 miles).

Statistics of the Bernese Alps Railways, relating also to single phase locomotives, report a larger proportion of accidents to the traction motors (insulation, commutators, brushes) and to the main transformers; followed by the current collectors and the organs of the mechanical portion.

In the 3 000-volt continuous current locomotives of the North of Spain Railway, the proportion of accidents to the mechanical portion and to the electrical portion is almost the same.

On the Italian State Railways the proportion of accidents to the mechanical part and to the electrical part is also almost the same, and in order of importance we find: current collectors, rheostats, switches, traction motors, speed controllers, cables, control circuits and auxiliaries, etc., while for the mechanical portion the most numerous accidents are hot connecting rod bearings and hot axle boxes, breakage of draw hooks during double heading etc. The consequences of accidents to the mechanical portion are also more serious than those of accidents to the electrical part.

## SUMMARY.

1. The replies to the questionnaire and the particulars which have been supplied to us on the different types of electric locomotives in service in Spain, Italy, Norway, Sweden, Switzerland and Cze-

cho-Slovakia, lead us to recognise, as has in fact already been stated by the various reporters of previous Congresses, that the electric locomotives, although the date of their introduction into railway service is now some decades past, do not yet present, even in their general lines, that uniformity of design which the steam locomotive, on the contrary, presented even a few years after its invention.

After having examined the numerous types of locomotives of the different systems, we have had to recognise the difficulty of setting forth on the one hand, within the limited terms of reference imposed on the reporters, all the questions and problems of design of the mechanical part and the electrical part, and on the other hand to arrive at conclusions having a character of generality.

The statements and conclusions have thus been limited to a few tendencies common to all the locomotives:

2. *Mechanical part.*

*The various systems of transmission* of the motion from the motors to the wheels do not present any substantial innovations, but improvements on types already known:

*a*) Direct drive by gearing and motors suspended by the nose is applied to almost the whole of the continuous current locomotives of low and medium speed. It is probable that this system will be extended also to single phase locomotives;

*b*) The individual drive of the axles by gears and motors fixed rigidly to the main frame appears in particular to suit high-speed single phase and continuous current locomotives;

*c*) The systems of drive by gears and connecting rods, applied for preference to single phase and three phase 45-period locomotives, seem particularly indicated for low and medium speed locomotives, when it is desired to push adhesion to the maximum, reduce the number of motors, and place them in a raised position on the frame;

*d*) The connecting rod drives are applicable when the motors, to the number of one or two, are of the low-speed type.

This is the case with some single phase locomotives and with the generality of the three-phase 16.7-period locomotives.

3. With regard to *the arrangement of the trucks*, bodies and switchgear, it is not possible to recognise common tendencies except for continuous current locomotives, as explained further on:

*a*) Total adhesion and non-articulated truck locomotives are utilised for the single phase and three phase systems if the speed does not exceed 60 km. (37.3 miles) per hour, and if the weight per axle is fairly limited;

*b*) Locomotives with total adhesion and articulated trucks, or composed of several motor bogies, are used almost everywhere for continuous current systems for goods and mountain traffic, as well as for passenger trains the speed of which does not exceed 90 km. (55.9 miles) per hour. Often the same type is employed for both low and high speed service, simply by adopting different gear ratios;

*c*) The use of bearing and leading axles is general for rigid truck locomotives which have to run at speeds exceeding 60 km. (37.3 miles) per hour.

This type is produced both for single phase and three phase locomotives and the continuous current type, with all the different systems of transmission;

*d*) The type with driving and trailing

axles and articulated trucks is generally adopted for locomotives with very considerable adhesive weight, generally with 6 motor axles and a limited weight per axle.

Experience has shown that the articulated coupling must permit only the rotation of each truck with relation to the other, and prevent any vertical or horizontal displacement;

*e*) The body arrangement which appears preferable from the point of view of supervision by the driver during running, and of the comfort and safety of the personnel, seems to be that with a central compartment enclosing all the apparatus, corridor on one or both sides, a driving position for each direction, and bonnets at the ends containing the compressors, rheostats, tools, etc.

4. It is generally recognised that the possibility of increasing the *weight per axle* facilitates the design and permits simpler and more economical types to be adopted.

*a*) This possibilty is more readily realised in electric locomotives with gear drive and motors rigidly carried on the frame chassis, which have no eccentric parts in motion, but in which, on the contrary, the centre of gravity is very high.

However, the maximum weight per axle of these locomotives does not exceed 21 t. (20.66 English tons).

*b*) For the locomotives with motors suspended by the nose (and generally for the types having the centre of gravity rather low and the weight not carried on springs) the weight per axle and the maximum permissible speed are lower than in the previous cases.

It is, however, to be remarked that the locomotives of this type have been designed for speeds of 100 km. (62 miles) and weight per axle of 18 t. (17.71 English tons).

5. The factors of adhesion found in practice on electric locomotives are higher than those used under the same conditions with steam engines.

A coefficient attaining 1/5 for continuous rating is frequently adopted, while a coefficient of 1/3 has been found several times in practice.

6. The consequences of bad *lubrication* on the cost of upkeep of the mechanical part are in general more detrimental in the case of electric than of steam locomotives, because of the larger number of bearings, often inaccessible, and starting difficulties with the motors, transmission system, axles, etc.

It is therefore recognised as of primary importance that the lubrication arrangements, in addition to ensuring economy of oil, should be automatic and reliable in action, above all for long distance locomotives.

## ELECTRICAL PART.

7. The use of *lightning arresters* is not considered essential on electric locomotives, except for the continuous current high tension types.

8. The working of *oil switches* on alternating current locomotives often presents difficulties, particularly in the case of violent short-circuits.

In view of the difficulty, due to lack of room, of getting completely satisfactory dimensions, certain administrations have recognised the necessity of limiting the working of the switches to current values which do not exceed those above which operation is irregular.

For the opening of short-circuits, it is, however, necessary to adopt arrangements which, preventing the locomotive oil switch from opening, will cause the

opening of the line sectionalising switches.

The necessity is recognised of establishing international regulations for the testing of the locomotive switches.

9. Although there exists a very great difference amongst the *speed control and starting apparatus* utilised on the different types of locomotives, the tendency is to use, on single phase and continuous current, electropneumatic contactor types.

10. The *transformers* are generally oil cooled.

The limit temperature admitted in the oil is 90° (194° F.) as a maximum, and 100° (212° F.) in the windings.

To prevent the accumulation of gases from the oil and explosion risks, it is indispensable to provide the transformers with ventilating arrangements.

11. The present tendency for single-phase and continuous current *traction motors* is to adopt the enclosed type, designed for high speed, and consequently the geared, or geared-connecting rod drive, while the open slow speed type is retained for recent three phase locomotives.

In presence of the general experience that the heating limits proposed by the Commission Electrotechnique Internationale cannot be adopted in current service, because they lead to too short a life of the insulation, the different administrations have adopted lower limits, so as to get a long life from the windings. These limits differ very slightly from those adopted for stationary machines.

It is, however, to be desired that the given power of a locomotive should be that which in reality can be developed in service, the heating limits being the same in all countries.

12. The *safety of the personnel* in service on the electric locomotives is menaced by two kinds of danger:

*a*) contact with the high tension conductors, determined by the necessity of inspection and repair during service;

*b*) explosion or flash from the switches and transformers or from short-circuits.

With the object of reducing these dangers to the minimum, it is considered indispensable:

I. — To adopt the most simple interlocking devices, which will not permit the personnel to come in contact with conductors ordinarily under voltage until after the personnel themselves have compulsorily accomplished the operation of cutting off the current and earthing the said conductors.

II. — To place apparatus liable to explosion, short circuits etc., in compartments with sheet steel walls, as far away as possible from the personnel.

*Extra high-speed locomotives.*

From the examination of the different high-speed locomotives, the tendency can be observed of adopting the type with leading bissel truck, individual drive of the axles by gearing, and motors raised and carried rigidly on the frame.

*High-speed locomotives.*

In this category it is not possible to observe a tendency towards any single type amongst the locomotives of different systems.

It appears, however, that the tendency to adopt articulated trucks with driving and trailing axles or an assemblage of several motor bogies with total adhesion and suspension of the motors by the nose is that preferred for continuous current locomotives.

For single phase locomotives, the single truck or articulated truck type, individual axle drive or geared connecting rod drive, seems the most common; while for the three phase 16-period locomotives the collective drive of the axles is exclusively employed.

*Goods and mountain locomotives.*

In this category a more marked tendency is observable to adopt collective drive of the axles by connecting rods for the single phase locomotives, also for the three phase, while for the continuous current locomotives the individual drive of the axles and motors suspended by the nose is generally employed.

The importance of regeneration is recognised, above all for three phase and continuous current locomotives, not only from the point of view of economy of energy on lines with heavy grades, but also from the point of view of maximum braking safety on long grades with continuous non-moderable brakes.

It is possible, in fact, to effect during regeneration or braking electrically the charging of the brake piping and auxiliary reservoirs, thus keeping up the most suitable pressure for heavy braking in an emergency.

The use of *multiple heading*, with a locomotive in front and one at the rear, is generally imposed less owing to the insufficiency of power of the electric locomotives than to the limited strength of the carriage or wagon couplings.

As it is desirable to avoid the use of locomotives at the rear of the train, it is important that the draw gear of the vehicles be made of sufficient strength so as to permit haulage with the locomotives at the front of the train.

*Operation.*

The statistics which have been communicated indicate in general that the proportion of electric locomotives out of service is less than that of steam locomotives, and that the annual mileages and those comprised between two repairs are very much higher.

The statistics of service accidents indicate that cases of trouble with the electrical part of the locomotives, although more numerous than those occurring with the mechanical part, are less serious from the point of view of regular working.

The necessity is, however, recognised of improving the details of the construction of the electrical part, and of increasing the coefficients of safety at present in force, with the object of reducing trouble still further, also of dimensioning as amply as possible the different mechanical organs.

# APPENDIX.

| RAILWAY. | Andalusian Railway Company. | North of Spain Railway Company. | | | |
|---|---|---|---|---|---|
| Nature of current: M. monophase-single phase; T. three-phase; C. continuous | T<br>25∿<br>5500 | C<br>3000 | C<br>3000 | C<br>1500 | C<br>1500 |
| Serial numbers | ... | 6000 | 6100 | 7000 | 7100 |
| Number in service | 3 | 6 | 6 | 12 | 10 |
| Types of locomotives | B + B | Co — Co | Co — Co | Co + Co | 1Co+Co1 |
| Transmission of motion between motors and wheels | EN | EN | EN | EN | EN |
| Ratio of gearing | ... | 1/4 | 1/3.39 | 1/4.94 | ... |
| Service: P. Passengers; M. Mountain; G. Goods | G. | G.<br>P. | G.<br>P. | G.<br>P. | P. |
| Length over buffers, in metres | 15.480 | 14.020 | 14.128 | 15.900 | 21.000 |
| Total wheel base, in metres | ... | 10.667 | 10.312 | 12 000 | 16.400 |
| Rigid wheel base, in metres | 4.000 | 3.505 | 3.962 | 4.450 | 4.450 |
| Diameter of driving wheels, in metres | 1.200 | 1.000 | 1.016 | 1.300 | 1.300 |
| Diameter of trailing wheels, in metres | ... | — | — | — | 1.036 |
| Side play on each side of driving axles, in millimetres | ... | ... | ... | ... | ... |
| Side play on each side of trailing axles, in millimetres | ... | ... | ... | ... | ... |
| Side play of pivot, in millimetres | ... | ... | ... | ... | ... |
| Centering force on pivot, kilogrammes | ... | ... | ... | ... | ... |
| Maximum speed in kilometres per hour | 25 | 60 | 60 | 90 | 90 |
| Total weight, tonnes | 50 | 80 | 75 | 102 | 110.7 |
| Adhesive weight, tonnes | 50 | 80 | 75 | 102 | 89.5 |
| Load on driving axles, tonnes | 12.5 | 13.3 | 12.5 | 17.1 | 15.1 |
| Load on trailing axles, tonnes | ... | — | — | — | 10.9 |
| Weight per lineal metre of length over buffers | 3.2 | 5.7 | 5 3 | 6.5 | 5 1 |
| Weight per metre of length of wheel base, tonnes | ... | ... | ... | 8.7 | 6.7 |
| Nominal power of locomotive, in kw. | 395 | 1 192 | 1 192 | 1 660 | 1 660 |
| Speed corresponding to nominal power, kilometres | 25 | 34.7 | 35.4 | 33 | ... |
| Tractive effort, one-hour rating, kilogrammes | ... | 12 600 | 12 500 | ... | ... |
| Power, continuous rating, kw. | ... | 1 162 | 989 | 1 310 | 1 310 |
| Speed corresponding to power at continuous rating, km. | ... | 35 | 35 | 35 | ... |
| Tractive effort, continuous rating, kilogrammes | ... | 12 120 | 9 600 | ... | ... |
| Maximum tractive effort, kilogrammes | ... | 24 300 | 18 750 | ... | ... |

| Czecho-Slovakian State Railways. | | | | | | Norwegian State Railways. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | C | C | C | C | C | M | M | M | M | M | M | M |
| 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 15000 16∽ | 15000 16∽ | 15000 16∽ | 15000 16∽ | 15000 16∽ | 15000 16∽ | 15000 16∽ |
| 4661 | 4650 | 4360 | 4240 | 4241 | 4230 | 2501 2502 | 2503 | 2001 2022 | 2023 2024 | 2075 2032 2047 2048 | 20.3 2034 2044 2046 | 2035 2043 |
| 1 | 2 | 4 | 2 | 2 | 1 | 2 | 1 | 22 | 2 | 5 | 5 | 9 |
| $B_0-B$ | $1A_0-B_0-A_01$ | $B_0\ B_0$ | $B_0-B_0$ | $B_0-B_0$ | $B_0-B_0$ | B + B | A A | B + B | B+B¹ | C+C¹ | ¹C+C¹ | B+B |
| EN | EN | EN | EBM | EN | EN | EN | EN | EBM | EBM | EBM | EBM | EBM |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| P. | P. | G. | G. | G. | G. | G. | G. | P. | P. | G. M. | G. M. | P. |
| 12.090 | 12.960 | 12.090 | 10.200 | 11.300 | 11.400 | 10.720 | 6.250 | 12.700 | 14.780 | 21.450 | 19.580 | 13.100 |
| 7.950 | 9.800 | 7.950 | 6.800 | 7.900 | 7.500 | 7.300 | 2.600 | 8 800 | 11.500 | 17.030 | 15.200 | 9 050 |
| 5 400 | 1.800 | 5.400 | 4.400 | 5.200 | 5.350 | 2.300 | 2.600 | 3.000 | 3.050 | 4.900 | 4.600 | 3.175 |
| 1.100 | 1.574 | 1.100 | 1.350 | 1.135 | 0.969 | 1 000 | 1.000 | 1.445 | 1.445 | 1.530 | 1.250 | 1.530 |
| — | 0.969 | — | — | — | — | — | — | — | 0.988 | 0.988 | 0.988 | — |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | . . | ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | . . | .. | . . | ... | 2×50 | 2×65 | 2×65 |
| . . | ... | .. | ... | ... | ... | .. | ... | . . | ... | 1 030 | 1 930 | 1 450 |
| 90 | 90 | 60 | 50 | 50 | 50 | 45 | 45 | 60 | 75 | 60 | 60 | 70 |
| 64 | 79.5 | 64 | 54 | 54.8 | 50 | 44 | 22 | 61.3 | 77.5 | 138.5 | 134.5 | 66.8 |
| 64 | 58 | 64 | 54 | 54.8 | 50 | 44 | 22 | 61.3 | 55.3 | 107 | 104 | 66.8 |
| 16 | 14.5 | 16 | 13.5 | 13.7 | 12 5 | 11 | 11 | 15.33 | 3.83 | 17.83 | 17.33 | 16.7 |
| — | 10 75 | — | — | — | — | — | — | — | 11.1 | 15 65 | 15.28 | — |
| 5.3 | 6 1 | 5.3 | 5.3 | 4.3 | 4 4 | 4.1 | 3.5 | 4.8 | 5.2 | 6 | 7 | 5 |
| 8 | 8 | 8 | 8 | 6.9 | 6.7 | 6 | 8.5 | 7 | 6 7 | 7.5 | 9 | 7.3 |
| 1 140 | 1 305 | 1 140 | 800 | 563 | 736 | 349 | 174.5 | 658 | 804 | 2 026 | 1 956 | 978 |
| 47.3 | 55.4 | 33 | 30 | 30 | 27 | 22 | 22 | 33.2 | 46.4 | 40 | 38.1 | 43.8 |
| 9 065 | 7 920 | 7 320 | 7 125 | 6 700 | 9 200 | 5 840 | 2 920 | 7 270 | 6 360 | 18 680 | 18 860 | 8 210 |
| 788 | 1 088 | 788 | 660 | 367 | 485 | ... | ... | 558 | 712 | 1 536 | 1 607 | 804 |
| 58 | 58 | 39.5 | .. | ... | ... | ... | ... | 37 | 47.2 | 46 | 40.3 | 43.8 |
| 5 100 | 5 750 | 7 380 | 5 000 | 3 700 | ... | ... | ... | 5 560 | 5 550 | 12 270 | 14 640 | 6 740 |
| . . | ... | ... | ... | ... | ... | .. | ... | ... | ... | ... | ... | ... |

| RAILWAY. | Swiss | | | | |
|---|---|---|---|---|---|
| Nature of current: M. monophase-single phase; T. three-phase; C. continuous. | M<br>15000<br>16~ | M<br>15000<br>16 | M<br>15000<br>16 | M<br>15000<br>16 | M<br>15000<br>16 |
| Serial numbers | Ae 3/5 | III<br>Ae 3/6 | II<br>Ae 3/6 | I<br>Ae 3/6 | Ae 4/7 |
| Number in service | 26 | 11 | 60 | 114 | 24 |
| Types of locomotives | 1Co1 | 1Co2 | 1C2 | 1Co2 | 1Do2 |
| Transmission of motion between motors and wheels | EAC | EAC | EBM | BB | BB |
| Ratio of gearing | 1:5 | 1:5 | 1:2.224 | 1:2.57 | 1:2.57 |
| Service: P. Passengers; M. Mountain; G. Goods. | P | P | P | P | P |
| Length over buffers, in metres | 12.260 | 13.700 | 14.090 | 14.700 | 16.700 |
| Total wheel base, in metres | 9.300 | 10 600 | 10.800 | 10.700 | 12.675 |
| Rigid wheel base, in metres | 4.200 | 4.200 | 5.700 | 4.000 | 6.850 |
| Diameter of driving wheels, in metres | 1.610 | 1.610 | 1.610 | 1 610 | 1.610 |
| Diameter of trailing wheels, in metres | 0.930 | 0.950 | 0 930 | 0.930<br>0.950 | 0.950 |
| Side play on each side of driving axles, in millimetres | 2×6 | 2×6 | 2×15 | 2×10 | 2×6<br>2×10 |
| Side play on each side of trailing axles, in millimetres | 2×83 | 2×70 | 2×83 | 2×83 | 2×95 |
| Side play of pivot, in millimetres | ... | 2×80 | 2×80 | 2×80 | 2×150 |
| Centering force on pivot, kilogrammes | ... | ... | ... | ... | ... |
| Maximum speed in kilometres per hour | 90 | 90 | 90 | 90 | 100 |
| Total weight, tonnes | 81.1<br>85.2 | 89.4 | 99.9<br>98.5 | 95 5<br>94.8<br>92.3 | 117.8 |

| | | Bernese Alps Railways. | | Swedish State Railways. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| M | M | M | M | M | M | M | M | M | M | M | M |
| 15000 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 |
| 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| II | III | | | | | *Oa* | | | *Oe* | | |
| *Ce* 6/8 | *Ce* 6/8 | *Be* 6/8 | *Be* 5/7 | *Pa* | *Pb* | *Ob* | *Oc* | *Od* | *Of* | Z | D |
| 33 | 18 | 2 | 13 | 2 | 2 | 17 | 2 | 10 | 21 | 1 | 50 |
| 1C+C1 | 1C+C1 | 1Co+Co1 | 1E1 | 2B2 | 2B+B2 | 1C+C1 | B+B | ODO | 1C+C1 | 2B | ... |
| EBM | EBM | EAC | EBM | B | EBM | B | EBM | EBM | EBM | EBM | ... |
| 1:4.03 | 1:4.03 | 1:5.866 | 1:2.23 | ... | ... | ... | ... | ... | ... | ... | 31:99<br>25:108 |
| M<br>P | M<br>P | P | P | P | P | G | M | M | M | P | P<br>M |
| 20.060 | 19.400 | 20.260 | 16.000 | 14.050 | 21.450 | 18.620 | 12.900 | 11.300 | 20 930 | 14.100 | 13.000 |
| 17.000 | 16.500 | 16.800 | 11.340 | 10 100 | 16.200 | 14.600 | 8.300 | 6 350 | 16.600 | 9 700 | 9.400 |
| 4 700 | 4.700 | 4.100 | 4.500 | 2.900 | 3.500 | 4.300 | 2.900 | 6.350 | 4.900 | 3.000 | 5.400 |
| 1.350 | 1.350 | 1.350 | 1.350 | 1.575 | 1.350 | 1.100 | 1.350 | 1 350 | 1.530 | 1.300 | 1 530 |
| 0.950 | 0.930 | 0.960 | 0.850 | 0.970 | 0.970 | 0.730 | ... | ... | 0.850 | ... | 0.970 |
| 2×25 | 2×25 | ... | 2×25<br>2×40 | ... | ... | ... | ... | ... | ... | ... | ... |
| 2×83 | 2×83 | ... | 2×115 | ... | ... | .. | ... | ... | ... | ... | ... |
| ... | ... | ... | 2×78 | ... | ... | .. | ... | ... | ... | .. | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 65 | 65 | 75 | 75 | 100 | 100 | 60 | 60 | 60 | 60 | 75 | 90<br>70 |
| 130.9 | 128 | 141.600 | 107 | 90 | 123.2 | 125 8<br>138 | 68 | 69 | 126.8 | 52 2 | 79.5 |

| RAILWAY. | Swiss Federa | | | | |
|---|---|---|---|---|---|
| Adhesive weight, tonnes | 55 5<br>55 9 | 55 | 56.5<br>55 3 | 56.1<br>55.9<br>55.3 | 76.8 |
| Load on driving axles, tonnes | 18.5 | 18.5 | 18 7 | 18.5<br>18 7 | 19.2 |
| Load on trailing axles, tonnes | 12 | 11.7 | 14.7 | 12 6 | 14 |
| Weight per lineal metre of length over buffers | 6.6 | 6.5 | 7 | 6 2 | 7 |
| Weight per metre of length of wheel base, tonnes | 8.8 | 8.4 | 9.1 | 8.6 | 9 25 |
| Nominal power of locomotive, in kw. | 1 300 | 1 300 | 1 460 | 1 400<br>1 550 | 2 050 |
| Speed corresponding to nominal power, kilometres | 63 | 63 | 65 | 61<br>65 | 65 |
| Tractive effort, one-hour rating, kilogrammes | 7 700 | 7 700 | 8 300 | 8 350<br>8 800 | 11 700 |
| Power, continuous rating, kw. | 1 150 | 1 150 | 1 230 | 1 210<br>1 390 | 1 800 |
| Speed corresponding to power at continuous rating, km. | 68 | 68 | 75 | 65<br>67 | 67 |
| Tractive effort, continuous rating, kilogrammes | 6 200 | 6 200 | 6 850 | 6 000 | 10 000 |
| Maximum tractive effort, kilogrammes | 140 00 | 14 000 | 1 500 | 14 000<br>15 000 | 20 000 |

| l). | | Bernese Alps Railways (*continued*). | | Swedish State Railways (*continued*). | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 108.4 | 103.9 | 114 6 | 80 | 33.4 | 63.2 | 98.4<br>105 | 68 | 69 | 100 | 31.1 | 51 |
| 18.8 | 16.9 | 19 | 16.5 | 16.7 | 15 8 | 16.7<br>17.5 | 17.3 | 17 25 | 16 8 | 15.55 | 17 |
| 11.3 | 12.1 | 12 | 13.5 | 14.15 | 15 | 13 7<br>16.5 | ... | ... | 13 | 10.55 | 13.7<br>14 8 |
| 5.4 | 5.3 | 6.3 | 6.7 | 6.3 | 5.8 | 7<br>7.4 | 5.2 | 6 1 | 6.1 | 3.7 | 6.1 |
| 6.4 | 6.3 | 8.5 | 9 2 | 8.8 | 7.6 | 8.6<br>9 4 | 8.2 | 6 1 | 7.6 | 6.8 | 8 5 |
| 1 800 | 1 640 | 3 300 | 1 840 | ... | 1 630 | ... | ... | ... | 2 050 | 330 | 1 210 |
| 35 | 36 | 50 | 50 | .. | ... | ... | ... | . . | ... | ... | 65<br>49 |
| 19 000 | 16 800 | 24 300 | 13 500 | ... | ... | ... | ... | .. | ... | ... | 6 600<br>8 800 |
| 1 600 | 1 350 | 2 700 | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 38 | 40 | ... | ... | ... | ... | ... | ... | . . | ... | ... | ... |
| 15 600 | 12 300 | 20 000 | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 30 000 | 26 000 | 34 000 | 18 000 | 8 000 | 16 000 | 20 000 | 16 000 | 16 000 | 26 000 | 6 000 | 12 000<br>16 000 |

| RAILWAY. | | | | | | |
|---|---|---|---|---|---|---|
| Nature of current: M. monophase-single phase; T. three-phase; C. continuous. | T 3700 16.7 ∿ | T 3700 16.7 ∿ | T 3700 16 7 ∿ | T 3700 16.7 ∿ | T 3700 16.7 ∿ | T 370 16.7 |
| Serial numbers | 550 | 551 | 552 | 554 | 360 | 38 |
| Number in service | 186 | 183 | 15 | 183 | 3 | [illegible] |
| Types of locomotives | OEO | OEO | OEO | OEO | 1C1 | 1C1 |
| Transmission of motion between motors and wheels | B | B | B | B | B | B |
| Ratio of gearing | ... | ... | ... | ... | ... | ... |
| Service: P. Passengers; M. Mountain; G. Goods. | M | M | M | M | P | P |
| Length over buffers, in metres | 9.500 | 11.010 | 9.700 | 10.800 | 11 540 | 11.54 |
| Total wheel base, in metres | 6.120 | 6.380 | 6.100 | 6.600 | 9.500 | 9.50 |
| Rigid wheel base, in metres | 3.840 | 4.100 | 3.600 | 3.700 | 4.700 | 4.70 |
| Diameter of driving wheels, in metres | 1.070 | 1 070 | 1.070 | 1.070 | 1.530 | 1.53 |
| Diameter of trailing wheels, in metres | ... | ... | ... | ... | 0.860 | 0.86 |
| Side play on each side of driving axles, in millimetres | 15 | 15 | 20 | 15 | 25 | 2 |
| Side play on each side of trailing axles, in millimetres | ... | ... | ... | ... | 60 | 6 |
| Side play of pivot, in millimetres | ... | ... | ... | .. | 25 | 2 |
| Centering force on pivot, kilogrammes | ... | ... | . . | ... | 1 600 | 1 60 |
| Maximum speed in kilometres per hour | 50 | 50 | 50 | 50 | 70 | 7 |
| Total weight, tonnes | 64 | 72 | 72 | 77 | 63.8 | 64. |
| Adhesive weight, tonnes | 64 | 72 | 72 | 77 | 43 | 4 |
| Load on driving axles, tonnes | 12 | 14.4 | 14.4 | 15.4 | 14.3 | 14. |
| Load on trailing axles, tonnes. | ... | ... | ... | ... | 10.4 | 10. |
| Weight per linea metre of length over buffers, t.. | 6.3 | 6.5 | 7.4 | 7.1 | 5.5 | 5. |
| Weight per metre of length of wheel base, tonnes | 10.5 | 11.2 | 11.8 | 11.6 | 6.7 | 6. |
| Nominal power of locomotive, in kw. | 1 500 | 2 000 | 1 600 | 2 000 | 600 | 1 20 |
| Speed corresponding to nominal power, kilometres | 50 | 50 | 50 | 50 | 65 | 6 |
| Tractive effort, one-hour rating, kilogrammes | 11 000 | 14 500 | 11 700 | 14 500 | 3 500 | 6 80 |
| Power, continuous rating, kw. | 1 300 | 1 800 | 1 400 | 1 800 | 500 | 1 00 |
| Speed corresponding to power at continuous rating, km. | 50 | 50 | 50 | 50 | 65 | 6 |
| Tractive effort, continuous rating, kilogrammes | 9 500 | 13 000 | 10 200 | 13 000 | 2 900 | 5 10 |
| Maximum tractive effort, kilogrammes | 12 000 | 15 000 | 14 000 | 15 000 | 8 500 | 8 80 |

te Railways.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | T | T | T | T | T | T | T | T | C | C | C | C | C | C |
| 00 | 3700 | 3700 | 3700 | 3700 | 3700 | 10000 | 10000 | 10000 | 650 | 650 | 650 | 650 | 3000 | 3000 |
| 7 ∽ | 16.7 ∽ | 16.7 ∽ | 16.7 ∽ | 16.7 ∽ | 16.7 ∽ | 45 ∽ | 45 ∽ | 45 ∽ | | | | | | |
| 30 | 331 | 332 | 333 | 431 | 432 | 570 | 470 | 472 | 620 | 320 | 321 | 420 | 625<br>626 | 326 |
| 16 | 18 | 6 | 40 | 37 | 40 | 4 | 4 | 10 | 5 | 5 | 12 | 1 | 14 | 2 |
| C1 | 2C2 | 2C2 | 1C1 | 1D1 | 1D1 | OEO | 1D1 | 1D1 | $C_o+C_o$ | 1C1 | 1C1 | $B_o+B_o$ | $B+B_o+B_o$ | $2C_o2$ |
| B | B | B | B | B | B | EBM | EBM | EBM | E | B | B | E | E | EAC |
| . | ... | ... | .. | .. | ... | ... | $^{43}/_{116}$ | $^{50}/_{112}$ | $^{15}/_{63}$<br>$^{23}/_{55}$ | ... | ... | $^{17}/_{56}$ | $^{18}/_{76}$<br>$^{19}/_{82}$<br>$^{34}/_{70}$<br>$^{22}/_{55}$ | $^{28}/_{104}$ |
| P | P | P | P | P | P | M | P | M<br>P | P | P | P | P<br>M | M<br>P | P |
| 008 | 13.370 | 13.370 | 11.600 | 14.510 | 13.910 | 11.500 | 14.550 | 14.800 | 11.700 | 12.770 | 12.770 | 10.180 | 14.900 | 16.300 |
| 400 | 10.600 | 10.600 | 8.980 | 11.610 | 10.710 | 6.380 | 11.610 | 11.600 | 8.300 | 10.000 | 10.000 | 8.980 | 11.550 | 13.200 |
| 600 | 3.600 | 3.600 | 4.180 | 2.350 | 2.100 | 4.100 | 2.350 | 2.300 | 3.100 | 5.200 | 5.200 | 2.083 | 2.450 | 2.450 |
| 630 | 1.630 | 1.630 | 1.630 | 1.630 | 1.630 | 1.070 | 1.630 | 1.360 | 1.060 | 1.500 | 1.500 | 1.040 | 1.250 | 2.050 |
| 960 | 0.960 | 0.960 | 0.960 | 1.110 | 1.110 | ... | 1.110 | 0.960 | ... | 0.950 | 0.960 | ... | ... | 1.110 |
| 15 | ... | .. | 10 | ... | ... | 15 | ... | 40 | .. | 15 | 1[illegible] | 10 | ... | ... |
| 90 | ... | .. | 90 | 105 | 105 | ... | 105 | 105 | ... | 75 | 75 | ... | ... | .. |
| 35 | 50 | 50 | 35 | 62 | 50 | ... | 62 | 62 | ... | 20 | 20 | ... | 100 | 150 |
| 950 | 2 340 | 2 340 | 3 370 | 3 200 | 2 150 | .. | 3 200 | 2 700 | ... | 1 850 | 1 850 | ... | 3 800 | 3 000 |
| 100 | 100 | 100 | 75 | 100 | 100 | 50 | 75 | 100 | 75 | 90 | 90 | 80 | 60<br>85 | 120 |
| 73 | 92 | 92.8 | 74.3 | 91 | 94 | 75.6 | 88 | 94.4 | 54 | 71.8 | 67 | 34 | 86 | 108 |
| 45 | 48 | 48 | 48 | 65 | 66 | 75.6 | 62 | 66 | 54 | 46.8 | 45 | 34 | 86 | 60 |
| 15 | 16 | 16 | 16 | 16.2 | 16.5 | 15.1 | 15.5 | 16.5 | 9 | 15.6 | 15 | 8.5 | 14.3 | 20 |
| 11 | 11 | 11.2 | 13 | 13 | 14 | ... | 13 | 14.2 | ... | 12.5 | 11 | .. | ... | 12 |
| 6.6 | 6.9 | 7 | 6.4 | 6.2 | 6.8 | 6.5 | 6 | 6.3 | 4.3 | 5.6 | 5.3 | 3.3 | 5.8 | 6.6 |
| 8.7 | 8.6 | 8.7 | 8.4 | 7.8 | 8.8 | 12 | 7.6 | 8.1 | 6.5 | 7.2 | 6.7 | 3.8 | 7.5 | 8.2 |
| 000 | 2 000 | 2 000 | 1 600 | 2 000 | 2 200 | 1 600 | 1 800 | 2 000 | 1 000 | 1 200 | 1 200 | 440 | 1 800 | 2 000 |
| 75 | 75 | 75 | 50 | 75 | 50 | 50 | 75 | 50 | 50 | 50 | 50 | 50 | 45<br>75 | 90 |
| 700 | 9 700 | 9 700 | 11 700 | 9 700 | 16 000 | 11 700 | 8 800 | 14 500 | 7 300 | 8 800 | 8 800 | 3 200 | $\frac{14\ 600}{8\ 800}$ | 8 100 |
| 300 | 1 800 | 1 800 | 1 400 | 1 800 | 2 000 | 1 400 | 1 600 | 1 800 | 1 800 | 1 000 | 1 000 | 440 | 1 800 | 1 800 |
| 75 | 75 | 75 | 50 | 75 | 50 | 50 | 75 | 50 | 50 | 50 | 50 | 50 | 45<br>75 | 90 |
| 700 | 8 700 | 8 700 | 10 200 | 8 700 | 14 500 | 10 200 | 7 800 | 13 000 | 5 800 | 7 300 | 7 300 | 3 200 | $\frac{14\ 600}{8\ 800}$ | 7 300 |
| 000 | 9 600 | 9 600 | 9 600 | 13 000 | 13 200 | 15 100 | 12 400 | 13 200 | 10 800 | 9 200 | 16 900 | 6 800 | 17 200 | 12 000 |

[ 625 .258 & 656 .212 .5

# REPORT No. 3

**(France, Italy, Portugal, Spain and their Colonies)**

ON THE QUESTION OF THE METHODS TO BE USED IN MARSHALLING YARDS TO CONTROL THE SPEED OF VEHICLES BEING SHUNTED, AND TO ENSURE THEY TRAVEL ON TO THE LINES IN THE VARIOUS GROUPS OF SIDINGS (SUBJECT X FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION (1),

By Mr. PELLARIN,

CHIEF ENGINEER, ASSISTANT TO THE CHIEF ENGINEER IN CHARGE OF THE OPERATING DEPARTMENT OF THE FRENCH EST RAILWAY,

and Mr. FARENC,

ASSISTANT OPERATING SUPERINTENDENT OF THE FRENCH MIDI RAILWAY.

Figs. 1 to 16, pp. 3073 to 3098.

We will divide this question into two parts :

1. Regulation of the speed of the vehicles shunted off;

2. Movement of the vehicles on the sidings in the yards.

## CHAPTER I.

### Regulation of the speed of the vehicles shunted off.

The first chapter will itself be divided into two parts :

*a*) Producing the speed required;

*b*) Regulating this speed in accordance with the different circumstances affecting the shunting of the wagons.

*a*) The speed required can be obtained by means of a locomotive which knocks off the vehicles, but this method is only possible on a very small output, seeing that between each shunt the engine has to stop in order that the points may be set between the wagons shunted off and that moreover when it has covered the full possible length of the shunting siding the engine has to return to the starting point in order to start again.

In all yards of any importance the method of propulsion used is by gravity. The gravity is utilised by means of a hump or of an incline which comes to the same thing as far as this point is concerned, if one considers what happens after the top of the hump or the highest point of the slope or the point from which the wagon starts on to this slope.

The slope over which the wagons are allowed to fall must fulfil the following conditions :

1. Be sufficiently steep so that at all temperatures the wagons will at least clear the farthest points;

2. Give a shunting speed as high as possible;

3. Not give the vehicles such a speed that it cannot be absorbed by the braking devices available.

The first condition is evidently difficult to realise when the fan of sidings has a great number of tracks since the

(1) Translated from the French.

development of the sidings is more extensive or the curves are more severe.

In order to get a satisfactory result the inclined plane should have immediately after its summit a very sharp, down slope and should show in the zone of the points a downward gradient sufficient to maintain the gravity effect either by being greater than the rolling resistance of the vehicles or at least to reduce the effects thereof.

In order to meet the second condition it is necessary that immediately after the inclined plane there should be a very sharp down gradient so as to separate the vehicles one from the other as quickly as possible. Seeing that the rolling resistance of the vehicles can vary according to their condition and according to temperature from 3 to 15 kgr. per t. (6.7 to 33 lb. per Engl. ton) approximately, a simple calculation shows that with a down gradient of the order of 50 mm. per metre (1 in 20) it is possible at the end of 40 m. (131 feet) to get sufficient distance between the wagons in order to be able to shunt them at the rate of 10 a minute even if the first points is placed at the above distance from the top of the hump.

On the other hand it is not desirable to have too steep a slope near the points, as if this is the case the vehicles run at too high speeds which cannot be absorbed by the braking appliances available or can only be absorbed at the price of very costly wear.

One is therefore led in practice to maintain the steepest part of the gradient on 50 to 60 m. (164 to 196 feet) only from the start of the slope and thereafter to reduce in the zone of the points the average slope to an approximate value of 5 to 10 mm. per metre (1 in 200 to 1 in 100), this latter being particularly advisable in places where the climate is cold or the winds very heavy.

The result is that if the first slope is sufficient to overcome under all conditions of weather and for all classes of vehicles the retardation effect in the area of the points, this retardation effect can be superior to the propelling force due to gravity and consequently when this area is extended [it may be 200 to 300 m. (656 to 984 feet) in certain kinds of sidings wherein the number of tracks exceeds 40], certain vehicles, bad runners, can reduce the intervals between them and the following vehicles which are running better to the extent of making it dangerous or impossible to move the points by which they should be directed on to the different lines.

Finally the vehicle when outside the area of the points and still having a certain speed should be stopped on its siding so as to be as close as possible to the vehicles already standing on this line without running into them at a speed which could cause damage either to the vehicle or to its load.

*b*) The above considerations seem to show that the problem of braking the wagons requires to be dealt with under three aspects, all rather different one from the other :

1. Seeing that the height of drop, which is determined by the need in all weathers and for all classes of vehicle to reach the farthest points when the atmospheric conditions are favourable, the possibility of reducing this height to avoid the vehicles shunted off having too high speed thereby requiring very heavy braking;

2. Maintaining between the vehicles shunted off, no matter what their running condition, the minimum interval required

in order to be able to operate the points. It is a question in this case of a sort of splitting up the wagons very analogous to that arranged for working trains over the main lines;

3. Finally arrangements made to stop the moving vehicles up against the standing vehicles and without shock.

The usual designs employed to meet these conditions whilst offering certain similarities have none the less appreciable differences. In order to reduce in good weather the height the vehicles drop it requires an apparatus which is not likely to stop them dead and consequently should simply be a speed reducer although normally run onto at slow speed. There is furthermore no need of a very great braking force for the reason given above.

The brakes employed by the railways consulted are in general brakes exercising a lateral braking:

— apparatus used by the French Midi at Narbonne;
— apparatus used by the French Nord at Longueau;
— apparatus employed by the French Est at Blainville.

The first two take the energy from water under pressure or compressed air, the third from electricity and springs.

They all include brake rails acting upon the inside face of the tyres or even on both faces and exercising on these faces a braking force moderated moreover in order to prevent any loosening of the tyres, a force which can be regulated according to the wishes of the operator on the Midi and on the Nord designs but which cannot be regulated on that used by the Est.

In addition to the braking resulting from the variations of pressure which can be exerted with the Nord apparatus, and with that of the Midi, it is also possible to regulate the braking effects by increasing the number of brake elements used.

This is the only method which is possible with the electric brake of the Est Railway, and which is used in practice on the Midi.

All these appliances are satisfactory in use and the reasons which recommend one or the other appear to be local.

The rail brake appears to be the most suitable of the kind seeing that the slipper brake or skid in stopping the axle picked up, is liable to stop the vehicle the speed of which and consequently the inertia at the time the brake acts are very low.

Moreover the vehicles at the moment of running on to the brake are still near one to the other and consequently it is necessary that the brake should have an action which can be considered as being continuous which is not the case when the slipper brake is used.

All these appliances which reduce the height of fall are situated near the top of the hump and are as a rule operated by an employee, who is responsible for stating the destination of the wagons. They therefore do not involve any additional labour.

The separation of the wagons should take place in the neighbourhood of the points on one or several rows of brakes according to the extent of the area over which the points are distributed. The apparatus te be used should therefore be capable of receiving a wagon already having a high speed of the order of 7 to 8 m. (23 to 26 feet) per second.

It should allow for this speed to be reduced in a proportion of at least as much as 3/4 and it should be fairly quick in action in order to be able to brake two

vehicles which follow one another and which are not separated by more than about 30 m. (98 1/2 feet).

The different railways consulted only employ as a rule slipper brakes. Some are considering the use of rail brakes with or without the automatic proportionality of the braking force to the weight.

The slippers employed in this zone should undoubtedly be automatically withdrawn, so as not to stop the vehicle. For this either the rail on which they slide should be fitted with a device for withdrawing the slipper from under the wheel, or there should be some other arrangements for removing the slipper at a given point.

The control of these slippers can be done either by hand by a brakesman who places them at a distance from the point at which the wagon is to stopped so as to obtain the braking force required to prevent any overrunning and not to allow the wagon to have more than desirable speed when leaving the area in which it is braked. Certain slipper brakes can be controlled electrically such as the Deloison and Dayon apparatus or the appliances used by the Midi Company.

Distance control is certainly the most desirable as placing the slippers by the man responsible requires a certain appreciation of the speed of the vehicle which is coming towards him and which can only be done as a rule just before the vehicle arrives, so that there is some danger.

Moreover, it is quite usual to utilise four throw off skids, put in position by hand by one man if the wagons are near together, but if they are far apart it is only possible to use one of two, whereas with distant control it is possible to put in position at least five or six by one man alone.

The increase of first cost which is about twenty five thousand francs per skid and falls to about 18 000 francs for the Midi's apparatus is consequently soon recovered.

In addition slippers put into position by hand when run on to at high speed by the vehicles especially if they are not upon a straight section of the line, may be thrown off and consequently have no useful effect. On the contrary slipper brakes controlled automatically being held practically against the rails do not show much defects.

On the other hand, as a result of the shock which they take and the speed of operation which is required their development has been difficult and this equipment is only now coming into current use in shunting yards.

The rail brakes like the slipper brakes can be used to brake wagons running at speed. If their method of construction does not make it possible to obtain a braking force proportional to the weight of the vehicle their regulation ought to be so carried out that light wagons can be braked without being derailed and consequently the brake may not exercise a sufficient braking force for heavy wagons.

The efficiency of these appliances in this way can be considerably reduced.

Certain arrangements make it possible to obtain with rail brakes an action proportional to the weight of the vehicle.

But if all danger of derailment of the vehicle is to be avoided when the vehicle runs on to the brakes at speed, it is desirable that the brake action should only be applied with force when the vehicle is in position on it, so that it is necessary to increase very appreciably their length. Under these conditions the first cost of these appliances is very high, of the order

of 150 000 fr., that is to say at least six times the price of a slipper brake controlled from a distance.

On the other hand they have the advantage of making it possible to regulate the brake force when the vehicle has run on to the brakes; the slipper brakes once engaged cannot be withdrawn except at a fixed point, and consequently there is some risk of stopping the vehicle, whilst the rail brakes can be released if it is thought the wagon has had its speed too much reduced.

It must be recognised however that this advantage is obtained at a very great cost seeing that there is no saving of labour as compared with the slipper brake operated electrically, and that with a little practice the operators of the latter succeed in using them with the skill required.

Furthermore if the fan of sidings is of great extent (35 to 40 tracks) the height of the hump and the extent of the zone of the points (250 to 300 m. [820 to 984 feet] at least), are such that a single braking appliance is insufficient, so that the slipper brakes can be placed on two or three successive lines and it is possible to correct on one of the subsequent brakes the insufficient braking of that preceding it.

On the contrary the rail brakes which are certainly more accurate in operation involve an enormously high first cost as their accuracy is not sufficient to give in a single line of appliances a proper regulation of the wagons over the wide distances occupied by the points in a fan of 35 to 40 tracks.

The rail brakes have also the advantage of better braking of eight wheeled vehicles whereas the skid slipper brake only brakes one pair out of four, but such vehicles are still little used in Europe.

Finally they can brake cuts of several wagons which is not so easily done with the slipper brake. The apparatus used by the Midi Company however, the operation of which is very quick, lends itself to the successive braking of the wagons of a rake and even the two bogies of one wagon.

In order to ensure the stopping of the wagons on their sidings, in a great number of cases all that is done is to place at a suitable position from the wagons already standing on the particular line, a slipper which completely stops the wagon as near as possible to the standing wagon.

This method however has the drawback that if excessive expenditure, due to insufficient use being made of the staff is to be avoided, it is necessary to make one man responsible for three to four sidings which are not filled at the same rate. The result is that the man can place in advance on each line a slipper at a suitable distance so that no shock or damage occurs even if the wagon arrives at speed, but if the wagon is at slow speed the wagon will be stopped far from those already in it and the capacity of the siding will be badly used, necessitating the wagons being closed together. Moreover if the irregularity in filling up the sidings is great the man will be obliged to make many journeys and will end by stopping the wagons at about the same position no matter what room there is behind them. It will consequently be essential to close up the wagons.

Now such closing up of the wagons unless it can be done by the special machines described in the second part of this report results in the shunting engine losing a considerable amount of time, and consequently considerably reduced output.

In addition the wagons that are stand-

ing at the top of the sidings are more liable to shock than if they had run further along them.

The drawback of this method is therefore a bad utilisation of the shunting sidings and an increase in the possibilities of damage.

It appears preferable to install at the beginning of each shunting siding a speed reducing brake of the kind described in the preceding chapter and to use it in such a way as to let the wagon after having run through it have such a speed that it will run to the wagons standing on the siding without appreciable shock.

In this way it is possible to get the wagons close together on the sidings.

These speed reduction appliances can be controlled by hand or electrically quite quickly: the man responsible for them will appreciate the speed to leave in the wagon to attain the above results.

When electric brakes are used the control is necessarily grouped together in a central cabin (as at Bordeaux-Saint-Jean or at Lille-Délivrance) in order to reduce to the minimum possible the number of shunters.

These appliances however are not wholly able to meet the requirements as they are subject to errors of judgment by the shunter, and if it be a question of slippers put in place by hand, to the latter being thrown off.

It is therefore prudent when using this method to retain a few reserve brakesmen naturally restricted in number (1 for 7 to 8 tracks) who can make good any mistakes committed or errors in braking and place in time a slipper under the wheels of a wagon running at too high speed in order to prevent collision.

The French Est Railway has just put into trial a braking appliance which is almost entirely automatic and which is dealt with in an appendix to this report.

This apparatus makes it possible to realise the method of braking mentioned above with the maximum of safety, seeing that the guided slippers cannot be thrown off, that the speed when leaving the apparatus is constant no matter what the speed when entering it, provided that it lies within limits which moreover are not exceeded in practice and that the speed, when leaving the appliance, is determined according to the number of wagons in the siding upon which the wagon is being directed and according to the atmospheric conditions.

A brake of this kind would reduce to the minimum the labour required. It would make it possible to check sufficiently the speed of eight wheeled wagons but lends itself less well to the braking of cuts of wagons. In the event of this appliance being used it would be necessary to shunt off wagon by wagon which could have certain drawbacks, and especially the overtaking of previous wagons.

It should be noted that as a rule the largest cut (more than two loaded wagons), ought to be accompanied by a brakesman, although this can be suppressed when there are braking appliances checking wagon by wagon.

The length of the brakes should be such that they can absorb the highest speed which can be given the wagons in practice when running onto them. The result is that the brake at the top of the hump should be short [10 m. (32 ft. 9 3/4 in)], but that those near to the points and those at the top of the sidings should have a length of up to 30 to 40 m. (98 ft. 6 in. to 131 ft. 2 in.), if it is a question of slippers placed by hand or by power and 20 to 25 m. (65 ft. 7 in. to 82 feet) if it is a question of rail brakes acting on all the wheels of the wagons.

When it is a question of using appliances with slippers having a fixed travel (as in the case of that used on the French Midi), it is desirable to examine the total travel of the whole of the appliances used each of which acts upon each wagon.

Finally it is necessary to supply the men responsible for braking the wagons with information as to the tracks upon which the vehicles are to be sent and as to their weights and their loads so that they can take the necessary steps to meet the conditions.

This result has been obtained by using luminous or sound signals.

In the first case a board is erected which gives by means of white or coloured electric lamps the number of the lines upon which the wagons are to be run, and indications regarding the weight, the fragility of the load and the men with the cut.

These boards are operated either after the hump or the signalling box.

It is also possible to use loud speakers of great power which can be heard at the sidings and operated also from the hump or from the control cabin.

These two systems have certain advantages as well as certain drawbacks.

The light arrangement is appreciably cheaper to fix up and to operate, it is simpler and does not require anything other than ordinary lighting equipment. It also gives the information for a longer period than a sound device; finally by a simple operation of the switch the information is given very quickly.

On the other hand the indications are necessarily more limited because they are limited by the possible combinations of the apparatus. Furthermore, they are not too visible in fog but they are not affected by outside noises, trains in motion, noises from the tractors, locomotive whistles, etc.).

Consequently the choice between these types of apparatus should be determined by local conditions. It would appear that in France the leaning is rather towards luminous signals.

### General conditions.

We have enumerated the various systems of brakes used and their method of employment. We have been able to note two main classes, the slipper brake — the rail brake. We have already enumerated the advantages and drawbacks of each system.

As regards the slipper brake its low first cost, the fact that it is proportional to the weight (other than in the case of eight-wheeled vehicles or rakes of vehicles) should be noted and also certain arrangements of such brakes as those on the French Midi Railway, which have not this drawback.

As regards the rail brake, it can be moderated and can be used for rakes of wagons and eight-wheeled vehicles but costs more unless it is only a question of a speed reducing device at the beginning of the slope. — It has been held against the slipper that it is violent in action and gives the vehicles running on to it a shock harmful both to the vehicle and to the load.

This error however should be corrected. The excess of shock due to running on to the slipper is negligible seeing that the variation of speed of the wagon at the moment of meeting the slipper is too small to matter owing to the relatively small weight of the slipper to that of the wagon.

As regards the effect of stopping it upon the axle it is the same as when the

wheels are picked up by the continuous or hand brake which has never been considered, except for tyre wear as having any drawback. As regards the wear of the tyres it is insignificant, the stopping of the wheels upon the slipper not being immediate and the length of brakage with the axle stopped not exceeding in practice about 15 m. (50 feet).

Finally the retardation effect of the axle braked upon its axle guards is not higher than that which occurs when braking a moving train.

Lifting on the slipper never occurs with slippers mechanically controlled and consequently secured to a frame attached to the rail if the running surface of the latter is satisfactory.

From the point of view of maintenance there is of course wear, but this wear corresponding to the work in braking produced is the same per kilogrammetre absorbed, whether it is a question of a rail brake or a slipper brake.

In this latter system it is almost entirely the metal of the slipper which wears, but it is easy to replace it. With the rail brake, it is possible to increase the wear of the tyres which is not without some drawbacks as regards their fitness for running.

In fact, braking by slippers appears in France, where the wagon with more than two axles is rare upon the fan of shunting sidings, to be most generally favoured owing to its simplicity and its low first cost.

### Operation of the brakes.

When it is necessary to use mechanical brakes it is natural to concentrate the working thereof in order to reduce the operating labour employed. One or several special braking posts are consequently installed.

It has not appeared possible as a rule to confide the workings of these brakes to the pointsmen, as even with the most perfected apparatus for operating the points such as the electrical route system in which the attention of the pointsmen is reduced to the minimum, they would not be able both to assure at large centres a proper shunting off of the wagons, and at the same time an efficient braking thereof.

The object to be attained in a shunting yard being an increased output it is of the greatest value to be able to shunt off the wagons very quickly — and the perfection of the method of checking the speed greatly aids therein, both by making it possible to use much steeper gradients on the hump and by better spacing the wagons so as to be able to operate the points quickly between them.

It can be taken that shunting 8 to 10 wagons per minute is quite realisable in good weather in a properly laid out and well equipped shunting yard. It is difficult to ask the pointsmen responsible for disposing of wagons at this rate to deal with the braking in addition, and consequently it is better to allot one or several men specially who will acquire the required ability.

The Midi Company proposes however in the particular case of a yard attached to the main traffic yard post, to confide to one particular man the operation of the points and the brakes of the Midi type.

In the operating cabin of the brake appliances it is always as well to give the men the following details : numbers of the lines upon which the wagons are going, particulars of heavy loads, fragile loads, etc., cuts accompanied by a brakesman, and finally the position with regard

to the number of wagons in the shunting sidings. The first indication can be given by the luminous boards or by the loud speakers mentioned above. The number of wagons can be indicated either by automatically operated clips controlled by the track circuits of the fan of sidings; or by simple indexes placed by the man dealing with shunting on information supplied by the head of the shunting service.

In any event, it is essential that the men responsible for braking the wagons should have a good view over the whole of the yard.

This condition is as a rule realised during the day.

At night it is indispensable to provide very good lighting so arranged as to meet this requirement. The costs of lighting are covered by better braking of the wagons.

## SUMMARY.

I. — The shunting of wagons in a marshalling yard requires some form of propulsion, very quick at the start so as to get the wagons separated and as sustained as possible to avoid the wagons stopping anywhere near the points. The speed resulting from this propulsion should be regulated, while running, as much more closely as the lengths to be run by the wagons is greater, that is to say as the points into the shunting sidings are spread over a greater area.

II. — It appears to be necessary to employ for this purpose appliances at the top of the pump in order to check, immediately after the wagons leave, any unnecessary excess of speed which may even be dangerous in good weather although needed in bad weather.

Near the points, one or several successive sets of brakes run over in turn by the wagons should be provided.

Finally at the beginning of the sidings should be placed a last set of brakes capable of preventing the wagons leaving except with just the speed required to run to the end of the available space on the siding without any harmful shock.

III. — These appliances shall be as far as possible mechanically controlled and even automatic in view of the advantages of safety and economy which result therefrom, the technique having solved in a very satisfactory manner the difficulties of operating the various types available.

IV. — The control of these appliances should be grouped into control boxes in which the man shall receive all useful information (numbers of the lines, kind of loads, brakesmen with the rakes, number of wagons in the siding).

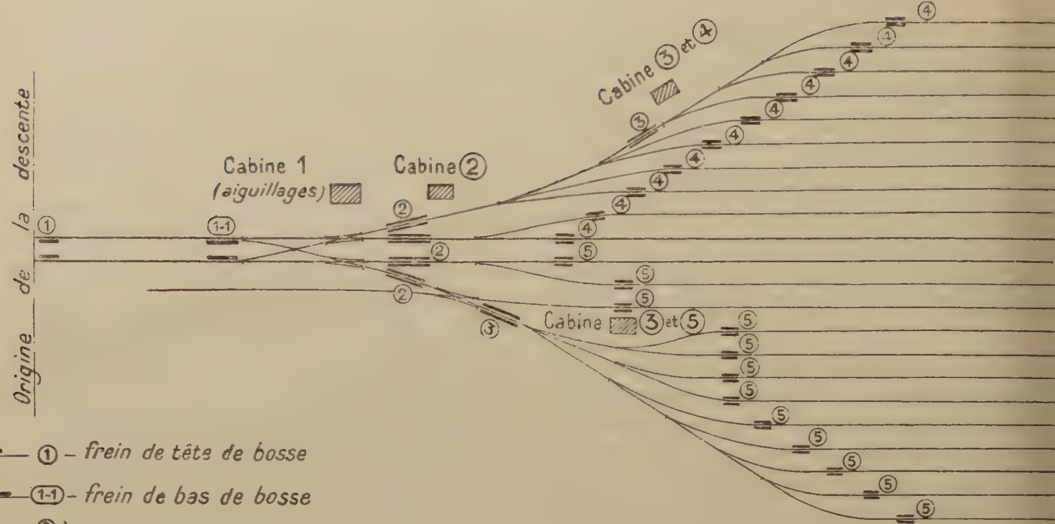
Below is given a layout of the brakes installed on an important fan of sidings.

V. — Finally several men can be left in the fan of sidings to carry out an emergency braking if the normal braking has been insufficient.

VI. — The whole of the measures above are only capable of giving good results if the men can have a sufficiently wide view over the shunting sidings to be able to decide upon the amount of braking to be given.

In the day time this condition is generally realised.

At night it is not always the case, and a really good lighting of the points leading into the group of sidings and the ends of the shunting sidings themselves is essential the resulting costs being recovered by the quicker working of the yard and the reduction in damage to the stock.




① – *frein de tête de bosse*

(1-1) – *frein de bas de bosse*

②
③ } – *freins régulateurs de l'espacement des wagons*

④
⑤ } – *freins destinés à obtenir l'arrêt des wagons sur les voies de débranchement*

1 – *cabine destinée à la manœuvre des aiguillages*

② – *cabine destinée à la manœuvre des freins ②*

③④, ③⑤ – *cabines destinées à la manœuvre des freins ③, ④ et ⑤*

*Si les freins ④ et ⑤ sont automatiques, la cabine ② peut assurer la manœuvre des freins ③ avec deux agents si le débranchement est très rapide.*

**Scheme of the brakes appliances in an important fan of sidings.**

*Explanation of French terms:*

Origine de la descente = Beginning of down gradient. — Frein de tête de bosse = Brake at the top of the hump. — Frein de bas de bosse = Brake at the bottom of the hump. — Freins régulateurs.., = Brakes for regulating the space between wagons. — Freins destinés à obtenir... = Brakes intented to stop wagons on the sidings. — (1) - Cabine destinée... = Cabin from which the points are oper[ated]. — (2) Cabine destinée... = Cabin from which the brakes (2) are operated. — (3) (4), (3) (5) Cabines destinées... = Cabins provided for o[perating] the brakes (3), (4) and (5). If the brakes (4) and (5) are automatic, the cabin (2) can cover the operation of the brakes (3) with two men [if the] shunting is very quick.

## CHAPTER II.

### Movement of the wagons on the lines of the various sections in marshalling yards.

We will only consider here matters relating to the movement of the wagons inside a particular yard.

The transfer from one yard to another is as a rule done with locomotives or tractors, the power of which should be suitable to the work to be done.

In the shunting yards we will consider two yards in which the movement of the wagons has the most importance, that is to say : The shunting yard. — The transhipping yard.

As regards the yards in which the trains are formed there is not properly speaking any movement inside the yard, but rather

an exchange between the shunting yard and the sidings in which the trains stand until despatched.

*Shunting yards.* — In the shunting yards the wagons are stopped on the line intended, either by themselves or by brakesmen or by running into the wagons already stationary therein. Except in this latter case, which has serious drawbacks if the shunt is violent, the wagons are not in contact which results in two difficulties : the sidings are not filled up properly, and the vehicles shunted off cannot be coupled up.

The incomplete filling up of the sidings does not make full use of the available capacity and has the same result as if the shunting sidings were too short. The result is that wagons are shunted into sidings that are full and it follows that the wagons are damaged or sent on to the wrong siding.

The impossibility of coupling the vehicles lengthens the time taken to form the train as the engine doing this work is obliged to close up the wagons and to wait while they are being coupled before drawing out the rake. Its time is wasted. It is therefore necessary to see that on the siding the wagons are brought in contact as soon as possible after they come into the siding.

There is no doubt that a slight slope (1 to 2 per $^{00}/_{00}$ contributes to this and should be provided, but it is not always possible to make certain that this slope will be sufficient for all wagons, especially in bad weather unless it is increased, when it would be liable to give rise to destructive shocks in good weather, with free running wagons.

The closing up of the wagons on the shunting sidings is usually done with a locomotive. This operation has the disadvantage of interfering with shunting during a period which is far from negligible and often varies from 33 to 50 % of the total time of shunting. It will be seen that a considerable loss of output from the yard is the result.

The large extent of this loss is explained by the fact that pushing up the wagons has to be done at very slow speed in order to avoid shock and prevent overrunning the points at the other end of the yard, and furthermore when passing from one line to another the engine has to run a considerable distance in the area in which the points are situated.

It is therefore most desirable to push up the wagons by a separate engine other than that used for shunting, and by a machine which does not run upon rails.

Tests made with capstans show that this was not a satisfactory solution of the problem, seeing that the pushing up movement may have to take place the full length of the shunting and a capstan has only a radius of action of about 50 m. (164 feet) even with bollards so that it does not completely solve the question.

Their use could only be of value in the neighbourhood of the points leading into the sidings in the group where they could be used to pull bad running wagons which had stuck on the points.

On the other hand road tractors can run the full length of the shunting neck and can cross the line at many places, seeing that all that is needed is to lay in level crossings using old sleepers.

By closing up the wagons it is possible to obtain an improvement of at least 30 % in the working of the shunting engine (or the shunting engines), and about 10 % in the output of the engines used for making up the trains.

The buffering up of the wagons is done without shock seeing that the tractor

cannot exceed 6 km. (3.7 miles) an hour when hauling the wagons.

It does its work without any danger to the staff, even crossing the line during shunting operations not being dangerous in any way, provided a warning signal enables the driver to know what are the sidings onto which the wagons will go. Furthermore an assistant using a slipper can protect the level crossings 50 m. away whilst the tractor crosses over. These precautions having been taken during the four years that the tractors have been used on the French Est Railway no accident to the staff has been recorded.

The tractor however has certain drawbacks. In spite of its very small width 0.98 m. (3 ft. 2 5/8 in.) so that it can run in the six-foot, is width measured from rail to rail has to be about 3 m. (9 ft. 10 1/8 in.). On the French Est Railway this width is 3.50 m. (11 ft. 6 in.).

It is necessary to remove the lighting posts or any other obstacles on every other six-foot.

Finally experience having shown that tractors with wheels were the better it is essential if they are not to bury themselves between the track, to lay down pathways which prevent the wheels in slipping from sinking down into the ground.

These pathways have been provided by using old sleepers cut in two and placed at right angles to the track. These half sleepers can be usually connected together by other sleepers taken from the track laid longitudinally to the track and acting as curbs. In this way a larger and more solid path is provided.

The sleepers are sunk their full depth and covered with ballast (about 7 to 8 cm. = 2 3/4 to 3 1/8 inches).

Naturally it is necessary to provide in the shunting yards a shelter for the shunters with a small shop and a stores, a ramp for loading up and an underground petrol tank with pump.

Special precautions are to be observed when working in snow if rubber tyred wheels are used, as these slip upon snow or ice.

It is necessary to return to the use of steel wheels with studs or to use the special anti-slipping devices using plates or clips.

The better way is however to have removable wheels, which has in addition the advantage of making it possible to replace the tyres with the tractor out of service for a very short time.

The rubber tyres reduce the shocks felt by the staff and give better adhesion than metal tyres on the loose soil in the six-foot, so that the wear is not so heavy as that with metal studded wheels.

The number of tractors used varies with the traffic to be covered and with the number of shunting sidings. In good weather the working of a fan of 35 sidings handling 3 000 wagons per day can be covered with two tractors, if the braking of the wagons is properly carried out.

The working of a fan of 25 sidings dealing with 15 to 16 000 wagons per day can be covered by a single tractor.

In bad weather a third tractor can be put into service with advantage.

The tractors should work during the same hours that the shunting engine is employed. They should do their work by day and furthermore it might be advisable if the shunting engine works in two periods of 8 hours, to use the tractors for two periods of 9 hours, in order to deal with lubrication, filling up with water and petrol taking about half an hour and that there may be a certain gap between the completion of the work by the locomotives and that done by the tractor.

It can be taken that the movement of

the wagons in the shunting area has been, by the use of road tractors of narrow width, very satisfactorily provided for and in a way which can materially increase the output of the shunting yards.

It is not advisable to have too powerful tractors as their petrol consumption becomes too great and in addition it is necessary to provide much more solid pathways. As furthermore the most important work to be done by the tractor consists in buffering up separate wagons it will be seen that a tractive effort of about 1 500 kgr. (3 300 lb.) and a power of about 12 H. P. is ample.

The cost of a road tractor of this kind is about 30 fr. per hour of work, taking into account interest and amortisation of the first cost, and of course of the operating and maintenance costs of the machine.

It may be taken that for equal output of shunting, one hour of tractor duties saves about one hour's work of the locomotive, the cost price of which is about 50 fr.

In addition for an equal number of machines the output of the shunting yards is improved at least 35 %, which is very important if it is realised that a large marshalling yard represents a first cost of something like 80 000 000 fr. and that in consequence there is every interest to get the maximum possible output from existing shunting yards.

The tractors built so far have petrol or paraffin engines. It would certainly be a good thing if it were possible to build them with accumulators as their tractive effort would be more regular and their cost of working lower the batteries being re-charged at low prices during hours when little electricity is being consumed.

The up-keep of the tractors when they are properly built is not costly. One fitter is sufficient per shunting yard; in practice the motor alone requires over-haul at the end of 2 000 to 2 500 hours work only.

*Transhipping yard.* — In the transhipping yard the problem is rather different. The shed in which the transhipping takes place has as a rule a line on which the wagons to be unloaded are put and $n$ parallel lines on which are placed the wagons to be loaded.

If it is desired to put $p$ wagons for unloading it is possible to put $np$ for loading.

If $m\ np$ is the number of wagons to tranship during the daily working period it will be seen that it is necessary to change $m$ times the wagons to be loaded and $mn$ times those to be unloaded.

As a rule, $m$ should not exceed 2, otherwise the transhipping installation would have to be extended or the number of turns of duty increased.

The movement of the wagons consists in feeding the unloading track which has to be done up to as many as ten times per day, the empty wagons withdrawn from this track being then put in place on the loading sidings.

Finally it is necessary to draw out these trucks and replace them.

The characteristic feature of these movements is the short length and as a rule not to involve very great loads.

Consequently it can hardly be recommended to do this work with a locomotive except possibly the first filling up of the siding before the day's work as an engine, even when of little power, is badly used, and it is necessary to prevent, owing to the risk of fire, any ordinary locomotive from passing under the shed.

On the other hand, the electric capstan lends itself quite well to these manœuvres, but the best solution consists in an electric traverser fitted with one or two cap-

stans as it makes it possible to readily transfer a wagon from one line to another without having to work it to the points.

The traverser naturally should have sufficient length to take bogie wagons, and capstans should have a tractive effort of about 1 000 kgr. (2 200 lb.).

It is thus possible by using the capstan on the traversers to draw out the empty wagons from the off-loading siding and, with the traversers, to put them directly on the loading line or on a holding siding.

The truck and its capstan make it possible to handle one by one the wagons, either emply or loaded, and consequently it is possible to get a working in the shed as continuous and as quick as possible.

## SUMMARY.

I. — For moving the wagons in the shunting sidings the road tractor of medium power (12 H. P. approximately, and of little width, 1 m. = 3 ft. 3 3/8 in. at most) satisfactorily solves the problem.

The tractor on wheels with rubber tyres appears to be the best.

II. — It is possible to conceive other solutions based upon the use of tractor cables or of rail motor trucks running along between the lines.

But these systems have the drawback of being of very great cost especially as they make it necessary to have in each six-foot a fixed plant the use of which is always incomplete, whereas the road tractor works wherever there is need of it, and so is never waiting for a job.

III. — As regards the transhipping yard, it is desirable to use a traverser electrically operated with capstans, because this equipment can be used to serve up to 10 tracks by being moved where its capstan can be usefully used.

This traverser should have sufficient length to take wagons with the greatest wheel base used on the railway.

*(July, 1929.)*

# Questionnaire relating to Question X and replies from the French Railways.

## SECTION I.

**General arrangements in shunting yards as regards the propulsion and movement of the wagons.**

(Attach a plan and if possible a gradient section.)

I. — *What are the methods used for propelling the wagons, (propelling by locomotives, propelling by gravity humps or by continuous down gradient)?*

**Replies.**

*Alsace-Lorraine Railways.* — Locomotives and gravity humps (layout of the Hausbergen hump, fig. 1 and plan of the yard, fig. 2).

*French Est.* — Gravity humps (layout of the Blainville hump, fig. 3 and plan of the yard, fig. 4).

*French Nord.* — *Shunting :* Propulsion through gravity, preferably by gradient but by hump when the gradient is only possible with great difficulty (fig. 5). *Formation and marshalling.* — By engines in a yard on slight slope.

*French Midi.* — Shunting by gravity hump.

*French State.* — Shunting by gravity hump.

*Paris-Orleans.* — Shunting by gravity hump.

*Paris, Lyons and Mediterranean Railway.* — Except one yard on continuous grade at Terrenoire, use everywhere gravity hump.

*Paris, Lyons and Mediterranean Railway, Algerian lines.* — Only one marshalling yard with gravity hump.

II. — *Particulars of the gravity hump or of the continuous gradient (gradients, lengths).*
*Particulars of the fan of shunting sidings.*

**Replies.**

*Alsace-Lorraine Railways.* — Maximum gradients 40/1 000 (1 in 25) for about 35 m. (114 feet), then 1 in 100, then 1 in 250 near the points.

*French Est.* — Gradient of about 60 mm. per m. for 40 m. (1 in 17 for 131 feet), 8 to 10 mm. for 150 m. (1 in 125 to 100 for 492 feet) then the area of the points and 2 to 3 mm. (1 in 500 to 1 in 333) subsequently.

*French Nord.* — Continuous gradient with fan of reception sidings on a gradient of 5 to 6/1 000 (1 in 200 to 166). Height at knocking off point 2.42 m. to 2.71 m. (7 ft. 11 in. to 8 ft. 11 in.).

*French Midi.* — Slope of about 30 mm. per m. for 30 m. (1 in 33 for 98 feet), 25 mm. for 45 m. (1 in 40 for 148 feet), 15 mm. for 30 m. (1 in 66 for 98 feet), 2 mm. for 120 m. (1 in 500 for 394 feet). Height of hump 2.50 m. (8 ft. 2 1/2 in.).

*French State.* — Initial slope 30 mm. (1 in 33); provision is made for future yards for 40 mm. (1 in 25) with speed reducers.

*Paris, Lyons and Mediterranean.* — Initial slope 20 to 25 mm. (1 in 50 to 1 in 40) up to the first points 10 mm.

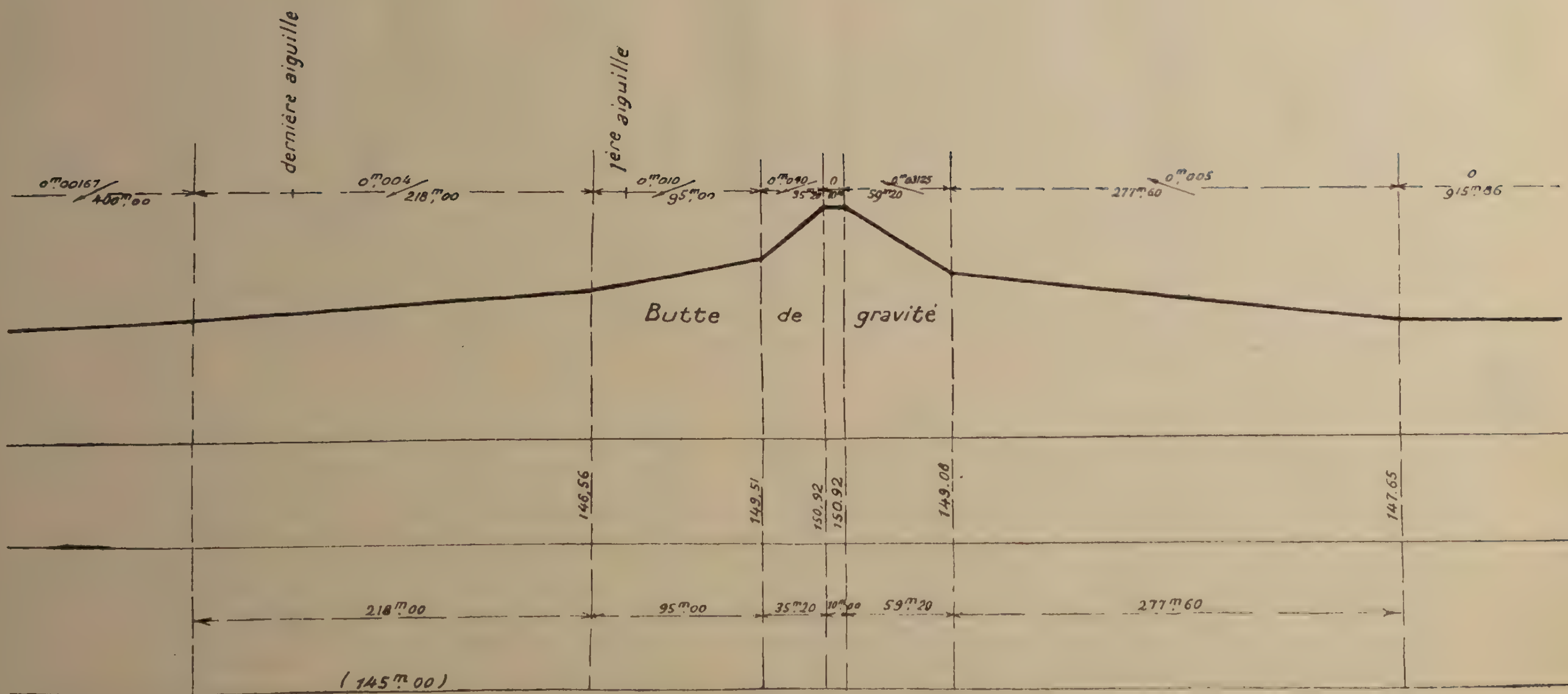



Fig. 1. — Hausbergen Marshalling Yard. Longitudinal section.

*Explanation of French terms:*

Dernière aiguille = Last point. — 1ère aiguille = 1st point. — Butte de gravité = Gravity hump.

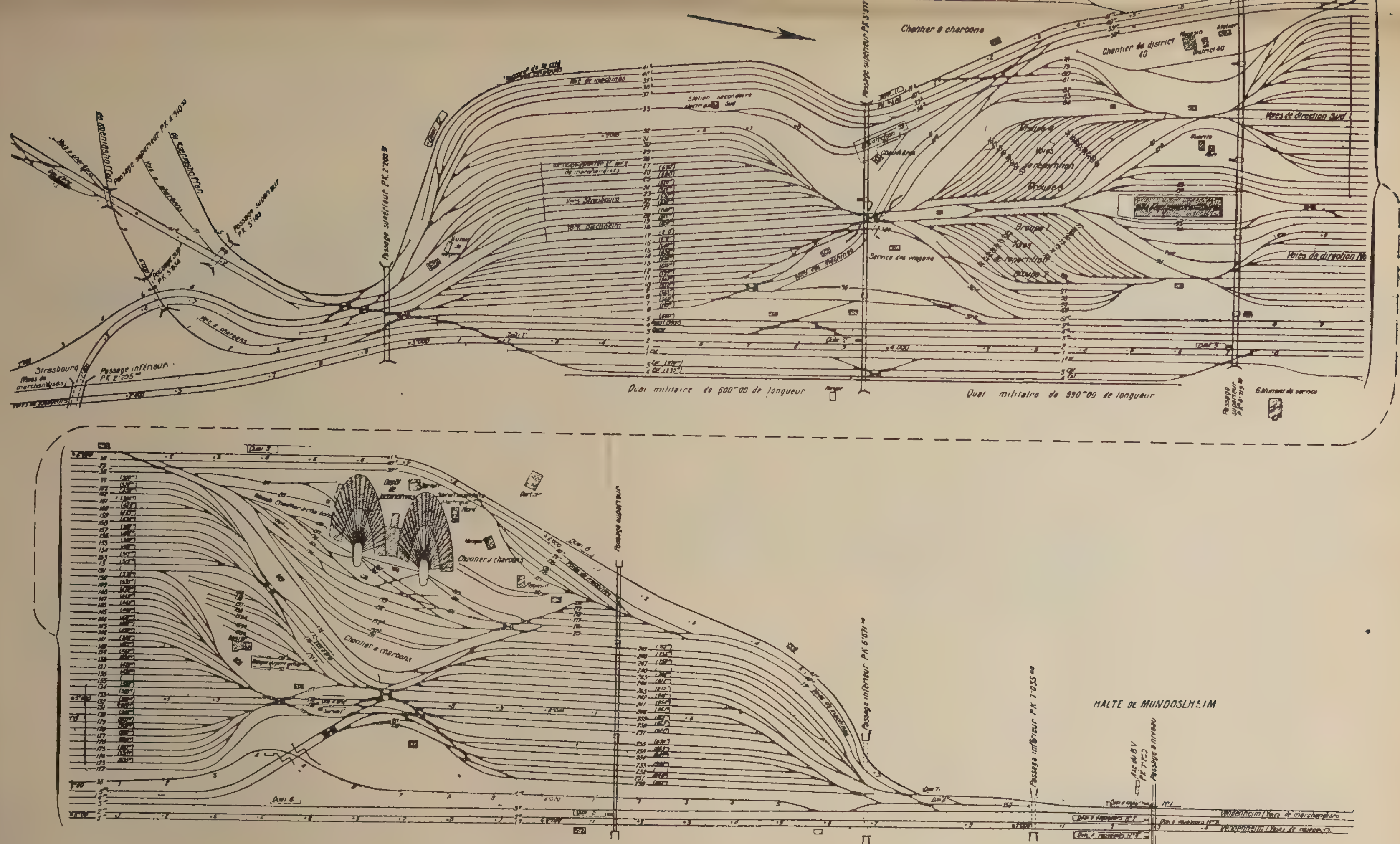



Fig. 2. — Hausbergen and Mundolsheim Yards. — General layout.

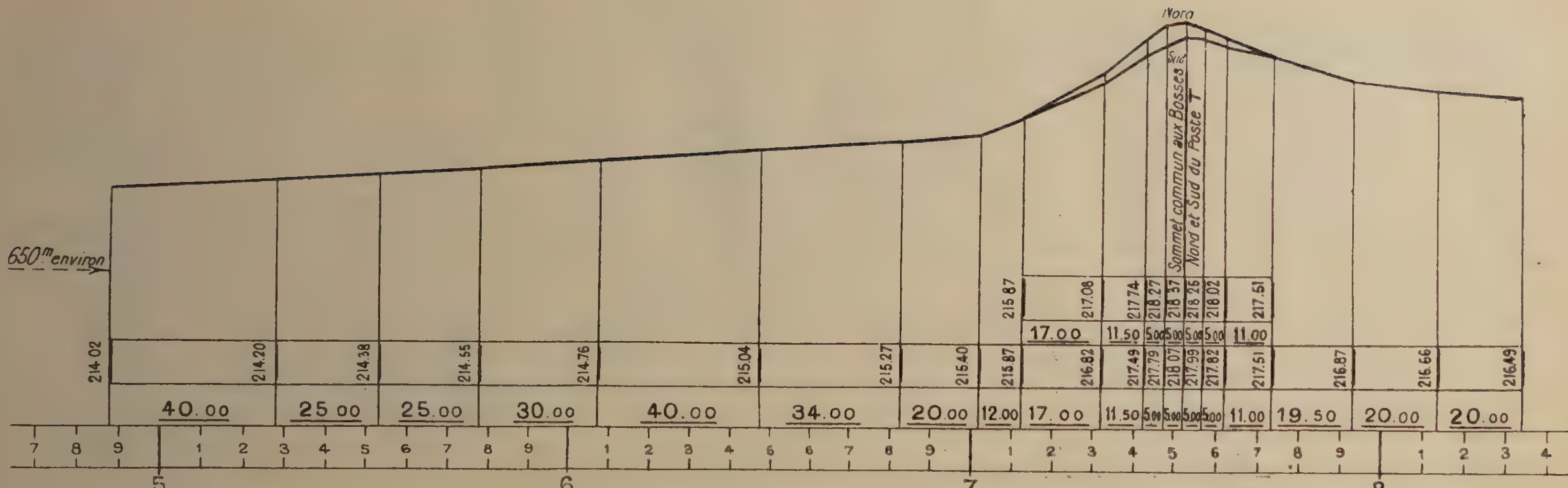



Fig. 3. — Blainville Marshalling Siding. — Profile of the hump and of the points in the section in which the wagons are shunted out.

Fig. 4. — Blainville Marshalling Yard. — General layout.

(1 in 100) for a length of 50 m. (164 feet) beyond.

The points into the marshalling sidings are controlled from a single signal cabin, and are distributed on a circle and grouped together as much as possible.

II. — *Is the area occupied by the points leading into the shunting sidings and the shunting lines themselves on a slope?*
*What is the length of the area occupied by the points?*
*Arrangements used to facilitate the running of the wagons into them...*

**Replies.**

*Alsace-Lorraine Railways.* — The area in which the points lie is on a down gradient of 4/1 000 (1 in 250), the shunting lines on a slope of 1.7/1 000 (1 in 588) for a length of 400 to 180 m. (1 310 to 590 feet).

*French Est.* — The points are on a slope varying from 5 to 10/1 000 (1 in 200 to 1 in 100). The shunting sidings are as much as possible also on a slope of 1 to 2/1 000 (1 in 500 to 1 in 1 000) for half their length starting from the points which are spread over a length varying from 2 to 300 m. (656 to 984 feet) in the big yards where the number of sidings exceeds 40.

*French Nord.* — The area of the points is on a slope of 5/1 000 (1 in 200).

The shunting siding on a slope of 1 to 3.5/1 000 (1 in 1 000 to 1 in 286) for a length varying from 170 to 550 m. (558 to 1 804 feet). Length in which the points lie as short as possible varying from 100 to 135 m. (328 to 443 feet) according to the number of lines connected together.

*French Midi.* — The area in which the points lie is on a slope of 15 mm. to 2 mm. (1 in 66 to 1 in 500). The tracks are level.

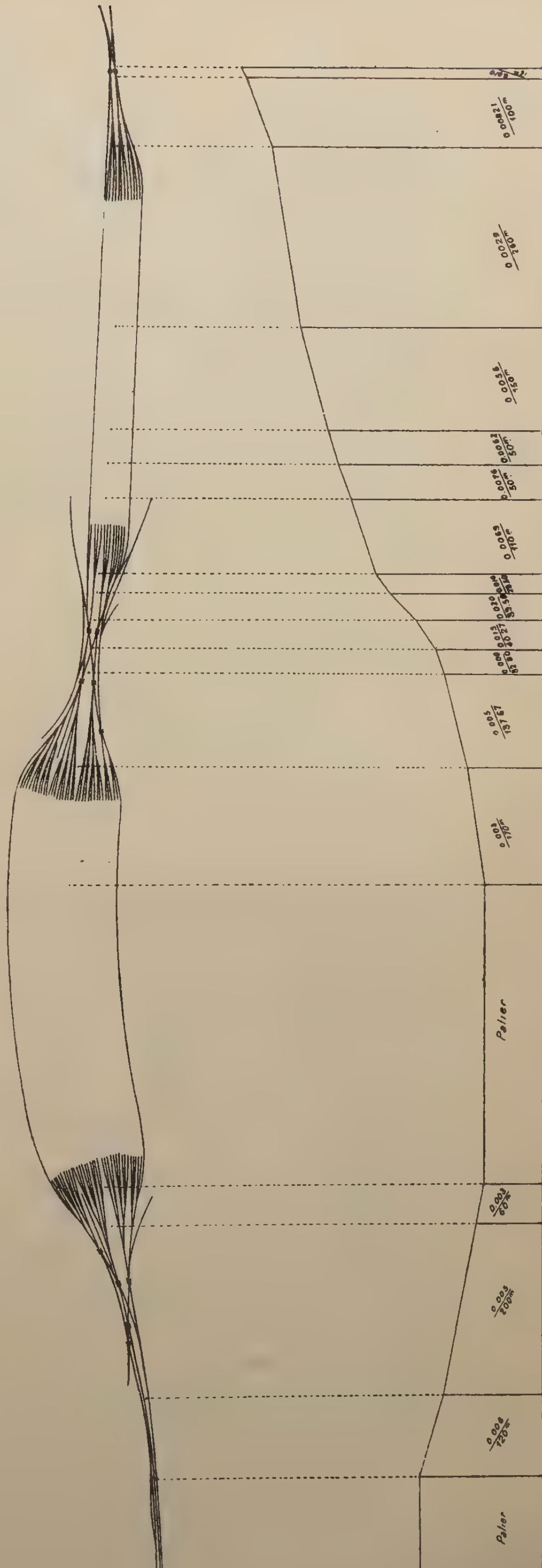



Fig. 5. — Lille-Délivrance Station. — Shunting by gravity. Plan and profile.

*French State.* — The area in which the points lie and which open out into the shunting sidings on a gradient of 5 mm. (1 in 200). The sidings are on the level.

*Paris, Lyons and Mediterranean.* — Slope of 5 mm. (1 in 200) near the points and from 2 to 3 mm. (1 in 500 to 1 in 333) on the sidings.

The length in which the points lie is 120 to 250 m. (394 to 820 feet) according to the number of tracks in the fan.

In order to facilitate the running of the wagons the lines on the straight between the hump and the first points with a symmetrical layout of the points, the maximum angle of which is 9 or 11.

## SECTION II.

### Methods to be used to regulate the speed of the vehicles when shunted off.

I. — *Do you use any appliances to regulate the speed of the vehicles shunted off?*

**Replies.**

*Alsace-Lorraine Railway.* — Slipper brakes are used.

*French Est Railway.* — 4 series of appliances :

1. At the top of the hump, an ACEC rail brake (Blainville, fig. 6) or at the bottom of the hump an electric slipper brake (Deloison) at Lumes.

2. In the area in which the points lie a series of electric slipper brakes of the Deloison type.

3. At the top of the shunting sidings the apparatus known as Rosenbaum's.

Finally beyond these, slipper brakes are used in order to stop vehicles the speed of which has been insufficiently reduced in the above mentioned appliances.

4. At the beginning of a siding and in place of a Rosenbaum appliance, an automatic speed reducer has been installed as an experiment. This apparatus (fig. 7) is built up of a certain number of elements arranged one after the other. Each element consists of a slipper moving along a slide. In the ready position, each slipper is at the beginning of its respective element. When a wagon approaches the slipper waits for it a certain time. If the wagon is going sufficiently quickly, it strikes the slipper and is braked for the length of the element. If the wagon is running sufficiently slowly, the slipper is removed automatically before the wagon reaches it, and the wagon is not braked. The waiting time of the different slippers is calculated in such a manner that by the successive actions of the different slippers of the apparatus the wagons shall have their initial speed reduced to such a value that they will have sufficient momentum to go so far as to come up against the wagons that preceded them. These waiting times should therefore vary as a function of the state of occupation of the sidings and this variation also is made automatically. Finally a manual combinator makes is possible to vary this function when the atmospheric conditions themselves change.

*Nord.* — In the case of the self-acting shunting slope the points at which the wagons are released are varied as needed to regulate the space between the vehicles. In the event of a hump being used (Longueau) a pneumatic brake with side jaws is used placed towards the top of the hump (at 28 m. = 92 feet).

Use is also made of slipper brakes which remove themselves at fixed points or at the wing rail.

*Midi.* — Three sorts of apparatus have been installed :

1. At the top of the hump Trayvou type rail brakes, used to reduce the height of fall.

2. Upon the slope and at the top of the sidings : slipper brake of the Midi

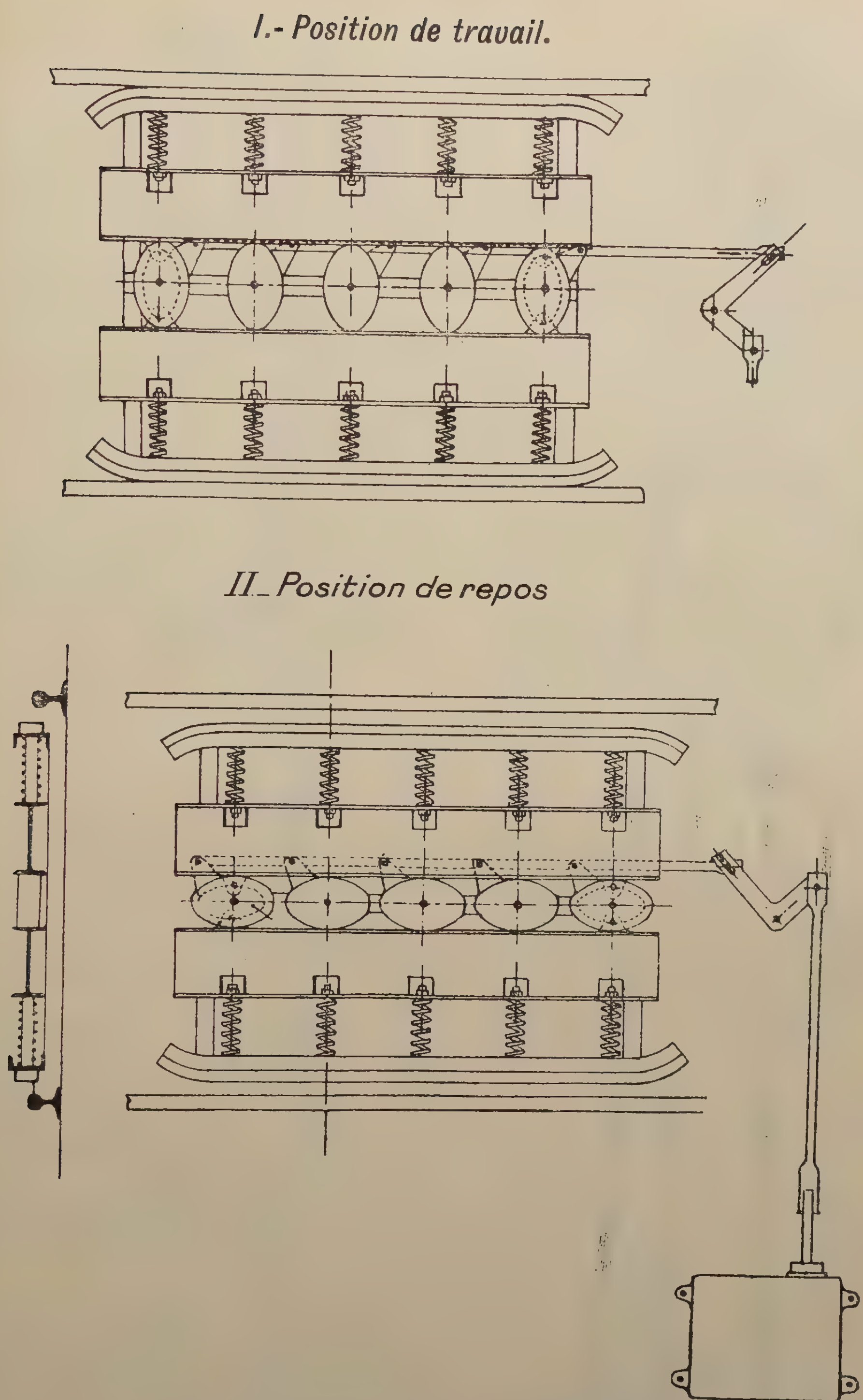



Fig. 6. — Blainville Marshalling Yard. — A. C. E. C. system segment brake.

*Explanat on of French terms :*

Position de travail = Working position. — Position de repos = Position when released.

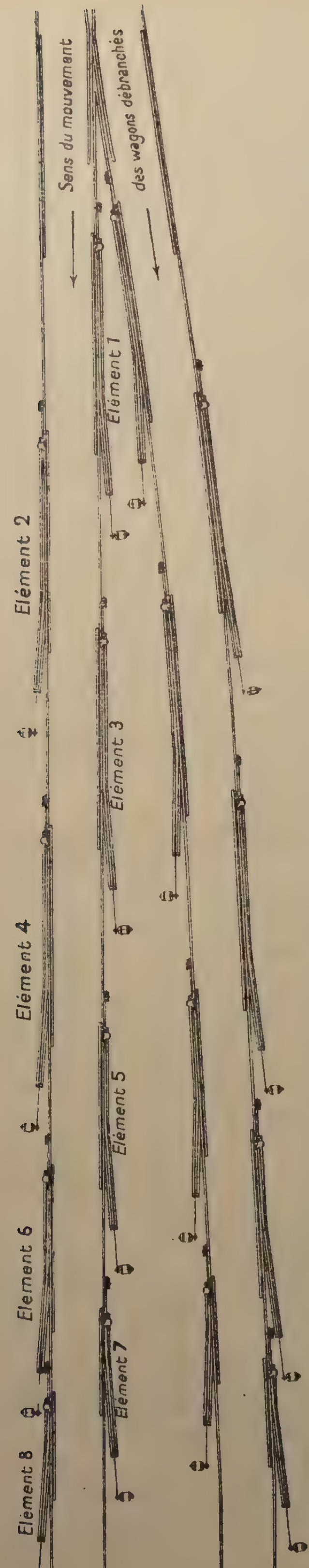



Fig. 7. — Blainville Marshalling Yard. — R. Apparatus.

*Explanation of French terms*: Sens du mouvement des wagons débranchés = Directions of movement of the wagons being shunted.

automatic system used to slow the speed of the wagons.

3. On the sidings : hand slippers used to stop the wagons if need be.

*State.* — The Trayvou system automatic rail brakes are used at the top of the hump to reduce the height of fall.

*Paris, Lyons and Mediterranean.* — Only use the hand slippers : are carying out tests of an American type of rail brake.

II. — *What are these appliances? Are they operated at the site, or from a distance?*

*Give particulars of the system briefly with a diagram. Mention the materials used, especially on those parts the friction of which causes the reduction of speed.*

**Replies.**

*Alsace-Lorraine.* — None.

*Est.* — The Deloison slippers and the ACEC rail brake are operated from a distance. The other slippers are used at the places needed.

The slipper which has given the best results (Elgéna slipper) is built up (fig. 8) as a unit as is the case of most brake slippers that is to say it consists of a slipper fitted with a pivoted ankle piece mounted on a sole, the latter being in two pieces; the front part is in a special very hard steel to increase the resistance to wear and to heating, and is fitted with guiding lugs. The back part, on the other hand, is in soft steel to increase the adhesion of the skid to the rails and consequently the efficiency of the braking action.

*Nord.* -- Dague system hump brake (fig. 9), Mr. Dague being an engineer of the Company. Formed by 2 longitudes 3 m. (9 ft. 10 1/8 in.) in length acting as brakes installed one on each

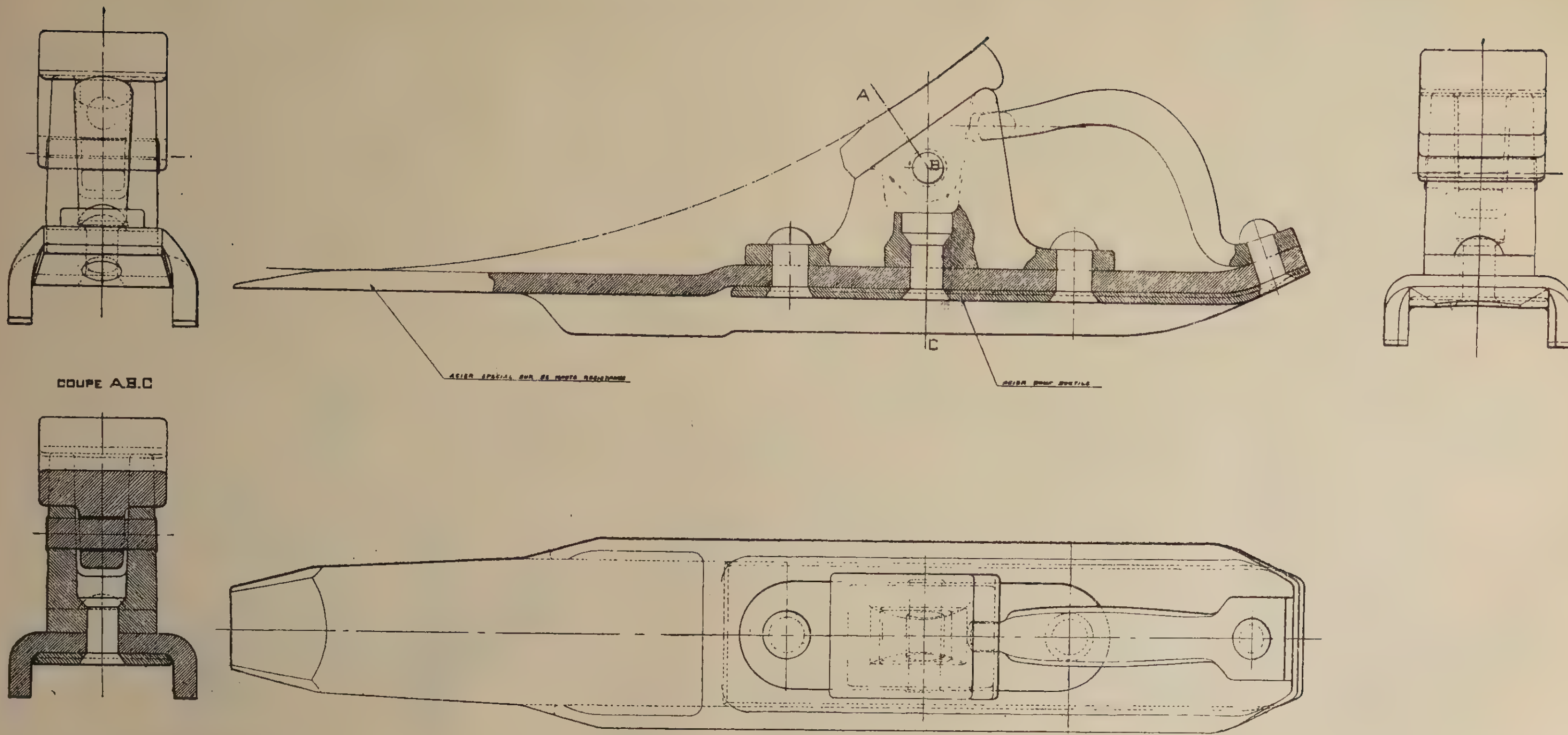



**Fig. 8. — Elgéna slipper with soft steel sole (patented).**

All parts of the slipper are of forged steel. Weight : 8.5 kgr. (18.7 lb.)

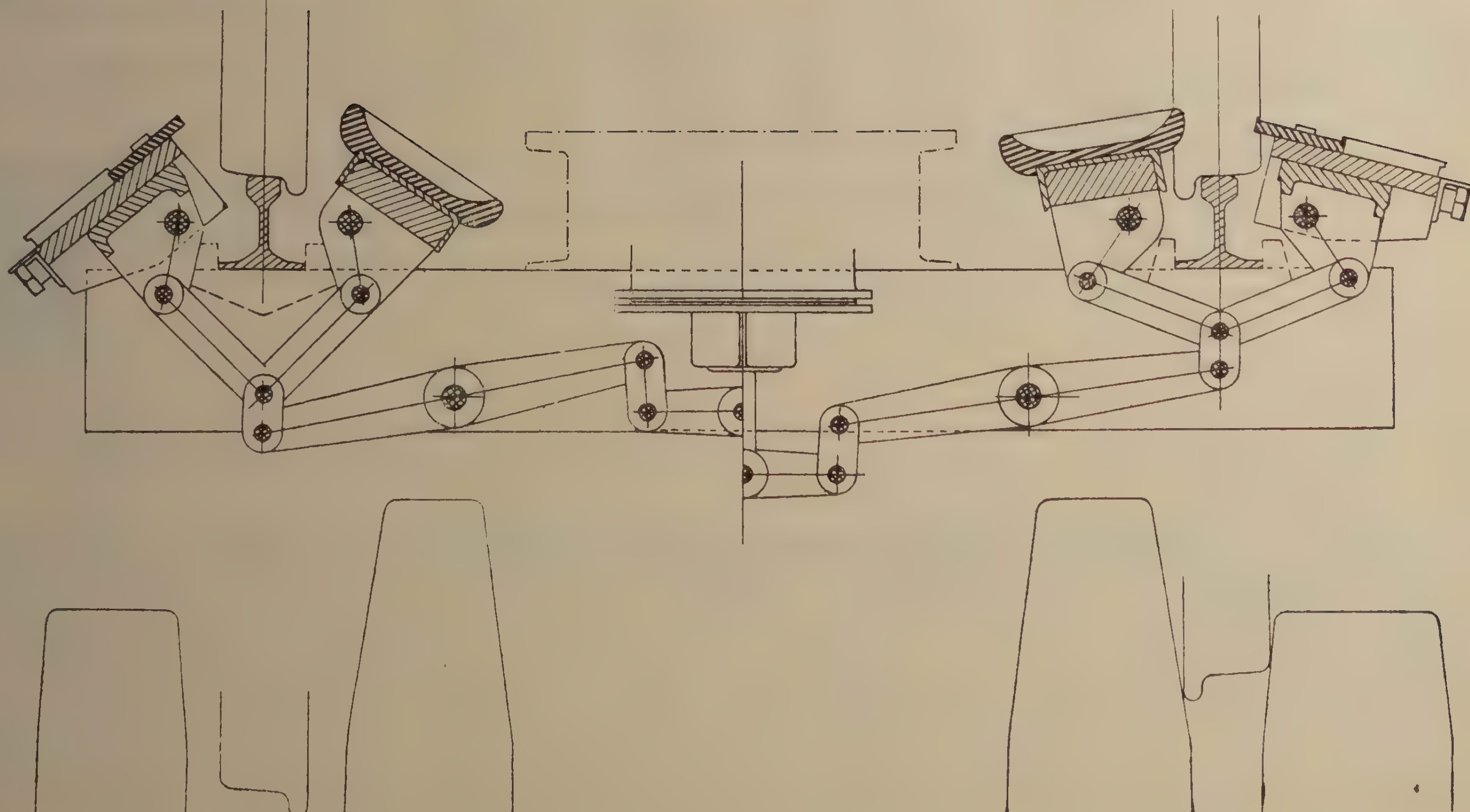



Fig. 9. — Longueau Yard. — Dague brake.

side of each rail. The braking part, in cast iron (inside rail), and in mild steel (outside rail). Controlled by cylinders — compressed air and rods and levers — the compressed air has a pressure adjustable by hand varying from 4 to (Deloyson and Dayon) were described in 8 kgr. (56.9 to 113.8 lb. per sq. inch).

The slipper brakes have a sole in chromium steel. The breaking strength 55 kgr. (34.9 Engl. tons per sq. inch); elastic limit, 36 kgr. (22.8 Engl. tons per sq. inch), elongation, 26 %.

The electrically controlled slippers (Deloyson and Dayon) were described in the *Revue Générale des Chemins de fer* (August 1924), and use a slipper of a type similar to that operated by hand. This slipper is pushed along the rails towards the wagon to be checked by means of a small carrier sliding on a guide and operated by an electric winch. The slipper is put into position by distant control — once the skid is in position the carrier automatically returns to its normal position. The slipper pushed along by the wagon is automatically restored to its place on the carrier.

Rail brakes which should be used near the top of the hump should be improved so as to absorb a momentum of 16 000 Kg.-M. (115 730 foot-pounds) with an apparatus having a length of 3 m. (9 ft. 10 1/8 in.) and of 35 000 Kg.-M. (253 160 foot-pounds) with an appliance of 6 m. (19 ft. 8 1/4 in.).

*Midi Railway.*

1. Trayvou system rail brakes. These appliances which were installed more than 15 years ago in the Narbonne yard are of the hydrodynamically operated type. Each apparatus consists of two check rails, one fixed, the other movable laid in the track. When the apparatus is not being used the outside gauge of the two check rails is less than the distance between the inside of the wheels of the vehicles. When the apparatus is ready for use the movable check rail is displaced so that the overall gauge of the two check rails becomes greater than the inside gauge of the wheels by 30 mm. (1 3/16 inches) except at the entrance into the appliance. To run through the appliance, the wheels move the movable check rail from the fixed check rail and operate consequently upon the pressure water contained in the pistons, and which is used to control the movable check rail. The pinching and frictional effect exercised by the wheels on the two check rails produces the braking of the wagon.

2. Midi system slipper brake. This appliance consists of a slipper guided by rods and able to move either on the rail when engaged by the wheels of a wagon, or alongside the rails when, after having acted upon the wagon it is restored to its initial position under the action of a spring wound upon the guiding rod.

It can in this way check, whilst running, each wheel of a rake. Thanks to a special device it can also brake as desired either the first pair of wheels alone, of each wagon of a rake, or the two bogies of any one wagon.

A description of the installation of these appliances at Bordeaux has already been published in the *Bulletin of the International Railway Congress Association* of December 1926.

*State.* — Trayvou system rail brakes described above and used to reduce the height of drop.

III. — *Theoretical considerations upon the braking effect and upon the output of such appliances.*

**Replies.**

*Alsace-Lorraine.* — None.

*Est.* — Checking the speed of the vehicles has for effect :

— At the top or the bottom of the hump to correct excessive speed which the slope of the hump gives in good weather.

— In the area in which the points lie, to maintain a suitable spacing between the vehicles which do not all run in the same way.

— At the beginning of the sidings, to let the vehicles run in only at a speed which is not dangerous.

In this way it is possible to shunt very quickly (7 to 8 a minute without risk of wagons over-running or of damaging one another.

*Midi.* — If by P is designated the weight of the pair of wheels braked by a slipper, $f$, the coefficient of friction of the slipper upon the rail, and $l$, the braking distance (distance run by the pair of wheels on the slipper) the work absorbed by braking is approximately equal to $Pfl$.

In the case of a rail brake (lateral friction on one side of each wheel), if we take P' as the pressure exercised by each piston upon the movable check rail, $l$, the length of the appliance and $f$, the coefficient of the friction of the check rails upon the wheels the work absorbed by the braking of a wagon can be calculated as being 3 $P'fl$ at most. Experience shows that this value is far from being reached in practice, so that for a heavily loaded wagon the braking distance required to stop the wagon is at least 50 % greater with the hydrodynamic rail brake than with the slipper.

IV. — *Give by class of appliance the first cost, the cost of maintenance and the cost of operating, and in particular the number of staff required to work each.*

**Replies.**

*Alsace-Lorraine.* —

*Est.* —

| | |
|---|---|
| ACEC appliances. . . . . | 35 000 fr. |
| Deloison appliances. . . . | 30 000 fr. |
| Rosenbaum appliances. . . | 3 000 fr. |
| Elgéna slipper brake, about . | 55 000 fr. |

The ACEC appliance is operated by a man already employed on other work. — 4 Deloison or 4 Rosenbaum operated by a single man.

*Nord.* — These appliances can be priced, as first cost, at :

35 000 francs for the rail brake at Longueau, of 3 m. (9 ft. 10 1/8 in.) length.

55 000 francs for one 6 m. (19 ft. 8 1/4 in.) long, and 25 to 30 000 francs per slipper of the Deloison and Dayon system.

The maintenance cost would be about 30 francs per 1 000 wagons braked for the first appliance, and 0.7 per 1 000 wagons braked in the case of the Deloison.

Three men are required to work 60 Deloison appliances.

The hump brake is worked by a man already occupied with other duties.

*Midi.* — The price of installation including all accessories is about 15 000 fr. for a rail brake element about 3.20 m. (10 ft. 6 in.) long.

The price of the slipper for 6-m. (19 ft. 8 1/4 in.) braking length is about 18 500 francs as first cost including the portion relating to the control cabin, to the electric and mechanical installations, to the announcing and communicating devices as well as a control device indicating that the siding at the lead in end is clear.

V. — *Methods used to obtain a rational use of the appliances. Do you use them systematically or only in isolated cases? What communication exists between the other men in the yard and those responsible for operating the appliances and especially how are the men kept informed of the work to be done?*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — The men operating the brakes are kept informed as follows :

A D. M. M. luminous signal apparatus

giving particulars of the sidings connects the top of the hump to the points operating and control cabin of the Deloison brakes (in certain cases), a Devillaine and Rouge luminous signalling appliance gives the same information to the men on the sidings, and sometimes also to the cabins from which the Deloison brakes are worked.

*Nord.* — The men responsible for working the appliances soon learn how to use them.

*Midi.* — The hydrodynamical rail brakes are used systematically as reductors of the height of fall. They can also be used usefully to reduce the speed and more particularly in order to complete after the vehicles have run through the rail brake, the braking done by these latter, the action of which is more energetic, but less readily adjusted especially when the wagons are running at very slow speed.

The automatic slipper brakes are used systematically for reducing the speed either with the object of regularising the speed with which the wagons run down or to stop them upon the siding.

The luminous indications keep the men responsible for reducing the speed both in the control cabin and on the job fully informed of the number of the track towards which the wagons are being sent.

*State.* — The use of loud speakers and of luminous signals gives the necessary means of communication between the various men.

*Paris, Lyons and Mediterranean.* — Ditto.

VI. — *Do you use a single complete appliance :*

a) *for each siding;*

b) *for a group of sidings;*

c) *for the whole of the sidings of the yard?*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — The Deloison apparatus is fitted to a line giving access to a group of other sidings.

Each of the shunting sidings is controlled by a Rosenbaum apparatus. At a later date apparatus controlled electrically will be installed.

*Nord.* — In order to completely equip a large yard such as Lille-Délivrance, it is necessary to consider the use of 60 Deloison appliances in three groups, so as to be able to brake each wagon three times in turn, the first time on a length of 20 m. (65 ft. 7 in.) the other times, 30 m. (98 ft. 5 in.) (fig. 10).

*Midi.* — A single rail brake appliance used to reduce the height of fall is placed near the top of the hump.

As regards slipper brakes used to check the speed they are arranged some at the beginning of a group of sidings and the others on each of the sidings.

*State.* — A single rail brake used at the top of the hump.

VII. — *Does the complete arrangement consist of a single appliance or of several?*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — A single appliance.

*Nord.* — The controls are connected together in a single cabin.

*Midi.* — The complete layout includes a group of appliances which can be worked individually.

VIII. — *Location of the appliances :*

a) *just below the gravity hump, — what distance from the end of the gradient?*

b) *on the sidings, — at what distance from the points?*

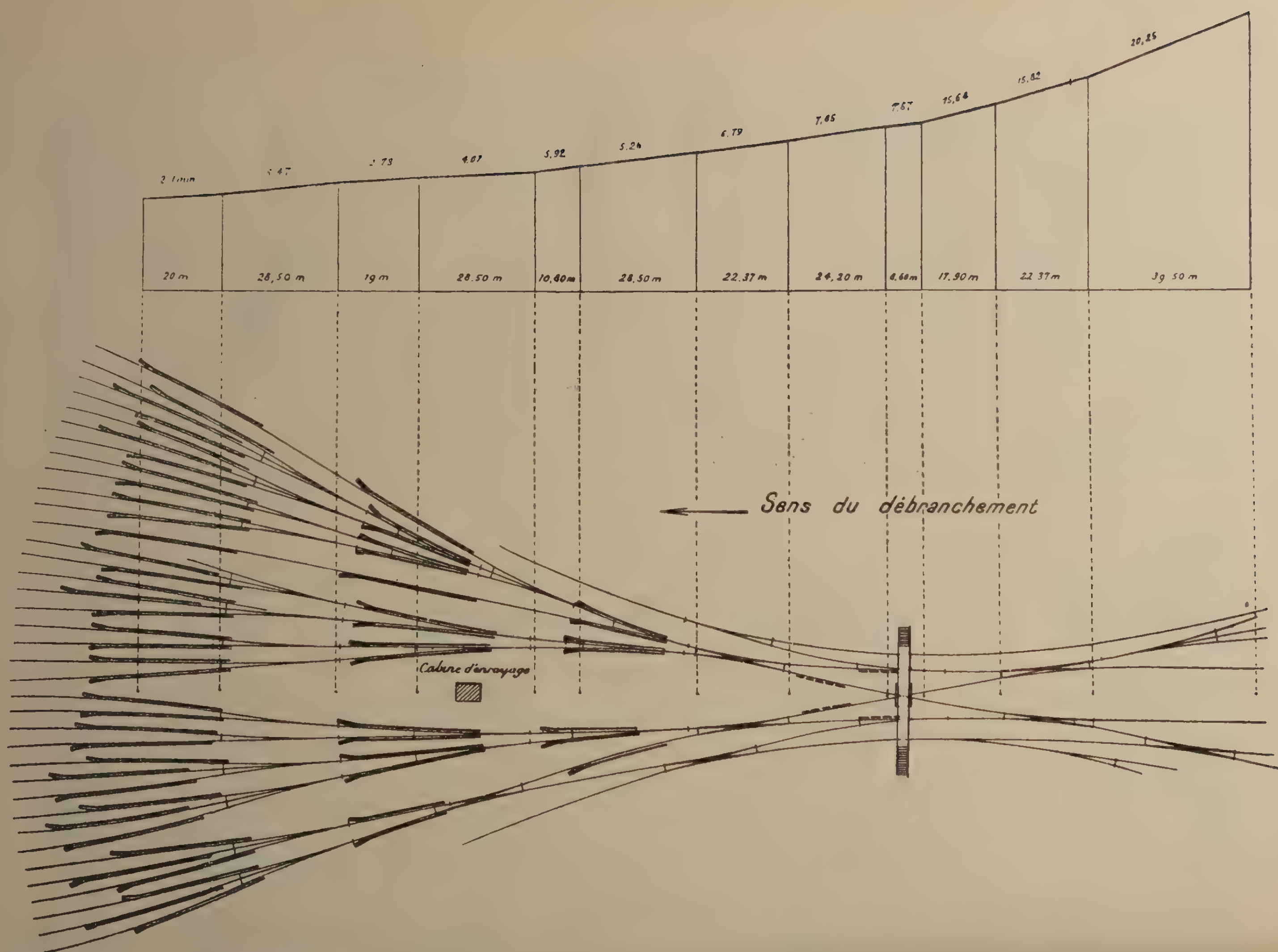



Fig. 10. — Lille-Délivrance Yard. — Deloison and Dayon retarders.

c) *on a slope, or on the level? Indicate the arrangements adopted for the most complete installation in use.*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — *a*) an ACEC appliance 10 m. (32 ft. 9 in.) from the top of the hump — or a Deloison appliance, the travel of which is 35 m. (115 feet), is taken on the down slope of the hump, the arrangements for throwing off the slipper being at a distance of several metres from the points of the first siding met with.

*b*) a series of Deloison appliances in an area of 30 to 35 m. (98 to 115 feet), reserved between 2 groups of sidings (see layout of Blainville, fig. 11).

*c*) Rosenbaum appliances, the signal of which is placed at about 40 m. (131 feet) after the points into the siding.

These appliances are placed either on the slope or on the level.

*Nord.* — See figure 10.

*Midi.* — The rail brakes used to reduce the height of drop are arranged at about 10 m. (32 ft. 9 in.) from the top of the hump.

The slipper brakes for reducing the speed are placed in groups of two or three :

1. in front of a group of sidings;

2. on each siding after the points.

*State.* — The rail brake used as a reductor of height of fall has been installed just below the gravity hump.

IX. — *Do you brake :*

a) *only the leading wheels of the vehicles?*

b) *all the wheels of the vehicles at the same time?*

c) *one after the other, all the wheels of the vehicles?*

d) *simultaneously the two wheels of a single axle?*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — Only the leading wheels of the vehicles on slipper brakes, and in this case only one wheel.

All the axles and all the wheels are braked in the ACEC type rail brake.

*Nord.* — Only the first pair of wheels of each cut is braked.

*Midi.* — The rail brakes brake each pair of wheels.

The automatic slipper brakes can in principle brake each pair of wheels but it has been considered better to use an arrangement by which it is possible to brake over a greater distance the first pair of wheels of each wagon, or the two bogies of bogie wagons.

*State.* — The rail brakes brake each pair of wheels.

X. — *How do you brake by means of the track brake, groups of vehicles? How many vehicles may there be in a single rake?*

*How do you brake two following rakes?*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — When there are more than three vehicles in a rake a brakesman travels with them. Up to this number they are braked as an isolated vehicle by using the brakes with their maximum power.

The speed of replacement of the slippers makes it possible to brake two successive rakes.

*Nord.* — Except special precautions

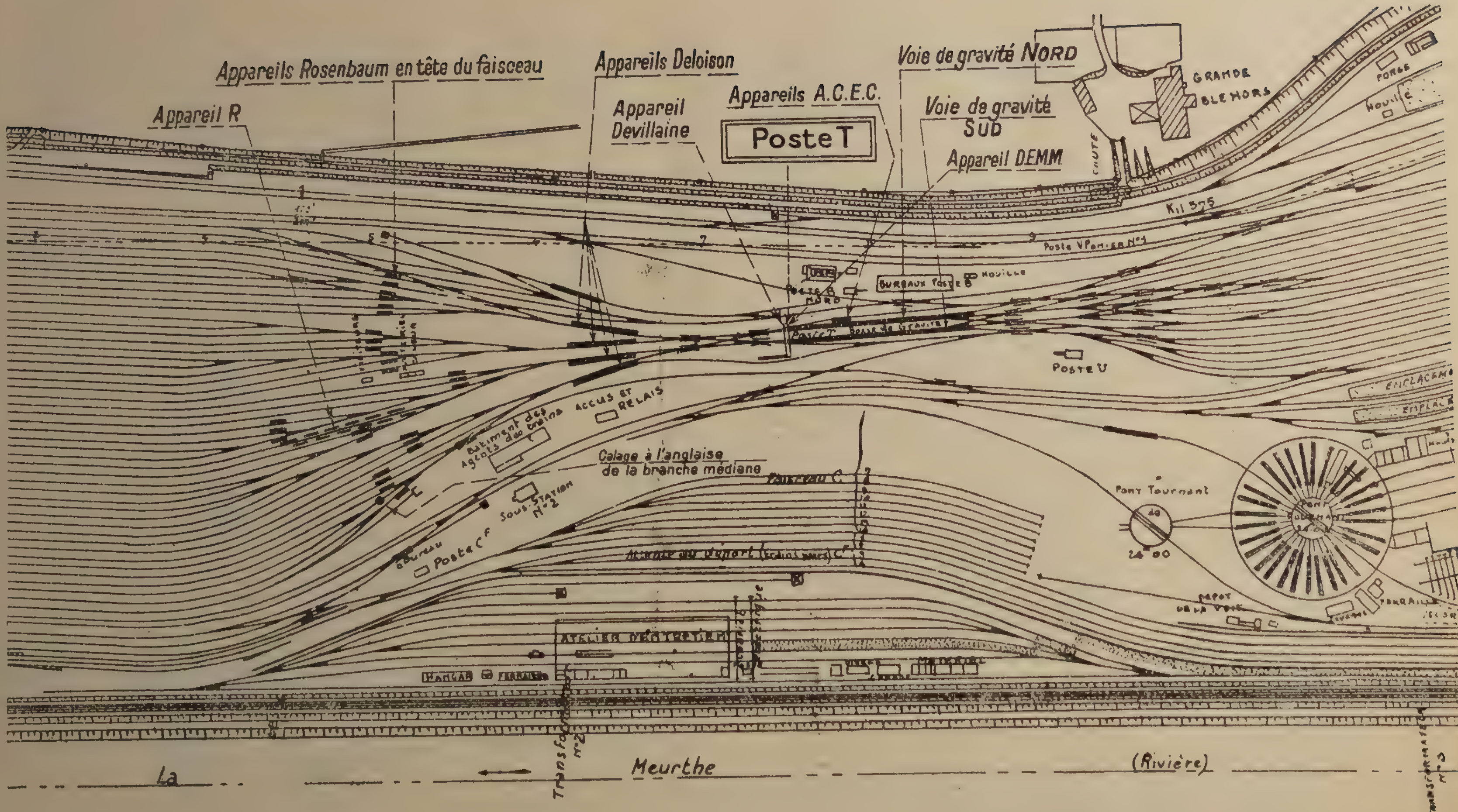



Fig. 11. — Blainville Marshalling Yard.

Shunting fan. — Positions of the various retarders.

are taken the rake shunted off should not exceed 60 tons in weight.

The slipper is put into position very quickly (6 seconds for the maximum distance of 30 m. [98 feet]) so that a slipper can deal with two successive rakes.

*Midi.* — As the appliances brake wagon by wagon it is possible to shunt off rakes of no matter what length without dividing them.

The slipper not being carried by a wagon except for a short distance always returns to its initial position immediately after the passage of the wagon, and protects it immediately against every other rake coming after it.

*State.* — The hydrodynamic rail brake can brake each axle.

XI. — *Is the braking controlled independently of the operation of the points? Why?*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — It has not been possible owing to the speed of the operations to make the same men control the brake appliance speed and operate the points.

*Nord.* — Independent operation. Nothing to be gained by connecting them together.

*Midi.* — In the large shunting yards the operation of the brakes is independant of that of the points. Simultaneous operation would seem to be possible in the case of a small fan. A test in this direction will be made shortly at Bordeaux.

*Etat.* — The working of the hydrodynamic rail brake is independant of that of the points.

XII. — *What results have you obtained?*

a) *Keeping the best intervals between the vehicles shunted off, and the repercussion of the methods used for reducing the speed of shunting;*

b) *Conditions of stopping the vehicle without harmful shock upon its siding whilst utilising to the best advantage the length of this siding. The length of the zone to be kept clear on the siding in order to make sure of stopping the wagons according to the size of the rakes shunted off;*

c) *Possible harmful effects of checking the speed upon the vehicles.*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — Notable speeding up in shunting (at the rate of about 8 wagons a minute), reduction of damage in the ratio of 3 to 1.

The sidings can be filled just up to the point at which the Rosenbaum slippers are taken off the line.

No harmful effect has been noted.

*Nord.* — Speed of shunting not increased (4 to 5 cuts per minute). The handling of the appliances enables a suitable spacing to be obtained.

The brakemen acquire such skill, that when leaving the last appliances for checking the speed of the wagons the speed will be just sufficient to get them to run up to the wagons already standing on the shunting siding without any harmful shock.

No damage noted. If need be, it would be possible to grease part of the rails.

*Midi.* — Speeding up of shunting as a result of being able to raise the humps in view of the ability to stop subsequently as required the wagons which were running at high sped.

The action of the Midi slipper brakes being practically proportional to the weight of the vehicles, it is possible to

run all the cuts under identical conditions of speed.

Reductions in the length in which the wagons are stopped, the rake being completely stopped soon after running through the last appliance, that is soon after passing the safe holding limit of the siding.

XIII. — *As a result of the use of braking appliances, has the shunting been increased, and by how many vehicles per 24 hours?*

*Has there been a reduction in the damages done when shunting?*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — The amount of shunting done has been largely increased, but it is difficult to attribute it to braking because at the same time the height of the hump was raised, tractors were introduced and a premium for good output granted; there has been an appreciable reduction in the damages caused in shunting.

*Nord.* — No effects upon the shunting, but a great improvement by reducing damage.

Marked reduction; in the proportion of 6 to 1.

*Midi.* — At Bordeaux the number of wagons shunted has increased from 6 to 9 per minute as the result of using slipper brakes.

The number of rough shunts has been reduced by more than 50 %.

XIV. — *Saving in staff as the result of using mechanical appliances.*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — These savings result from the use of the Deloison appliances, 4 Deloison appliances being looked after at the head of the fan by one man, whereas with the Rosenbaum appliances it was necessary to have 2 for each 8-hour turn of duty.

*Nord.* — Hope to obtain a saving of 18 men at least, — and possibly 22.

*Midi.* — At Narbonne the raising of the hump together with the installation of hydrodynamic rail brakes making it possible to reduce the height of fall at will has made it possible to considerably reduce the staff used during violent winds for pushing wagons which had not cleared the crossings.

At Bordeaux the use of the Midi type slipper brake has made it possible to obtain the same results. In addition a saving of 50 % has been obtained on the staff used for stopping the wagons.

XV. — *General considerations. Advantages and drawbacks that led you to adopt this or that arrangement.*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — Enquiries have been instituted with a view to finding simple and sturdy appliances and not too costly.

The use of the slipper has generally appeared preferable whenever there was any question of vehicles coming together at speed.

*Nord.* — The Deloison brake appears to be the best owing to the ease with which it is installed and its simplicity in use. Experience shows that the men soon learn the amount of braking to be given.

*Midi.* — The hydrodynamic rail brakes of relatively low cost and of which the regulation and operation are particularly supple appear to be very suitable for reducing the height of drop.

The Midi system slipper brakes have been adopted for reducing the speed of the wagons because :

1. Their use does not add any new feature to the methods already used in the shunting yards, and make it possible on the contrary to shunt off rakes of no matter what composition without dividing them;

2. Owing to the fact that the braking effort is proportional to the weight of the rakes, it gives particular facilities for reducing the speeds of all the cuts uniformly;

3. It does not require any previous appreciation of the amount of braking necessary as it is sufficient after each partial braking by an appliance to notice from the running of the rake braked whether it is necessary or not to use the other brake still available;

4. Each wagon braked is immediately protected against the following wagon;

5. The laying in of each appliance only requires a short length of track;

6. The distance in which the wagons are stopped is reduced to the minimum;

7. At equal stopping efficiency, the cost of installation is less than that of the other systems.

## SECTION III.

### Measures intended to assure the movement of the wagons on the sidings in the different yards.

I. — *What methods do you use to move the wagons on the sidings in the different yards :*

a) *Gravity;*

b) *Use of mechanical means (locomotives, tractors, capstans, ropes, motors, traversers, transporters)?*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — Setting back by gravity with powerful locomotives having 4 or 5 pairs of coupled wheels.

On the shunting sidings the wagons are closed up together by means of road tractors 0.90 to 1 m. (2 ft. 11 1/2 in. to 3 ft. 3 3/8 in.) wide running between the lines and crossing the tracks on level crossings made with old sleepers.

In the tranship yard an electric traverser with capstan, and separate electric capstans with bollards are used (fig. 12).

*Nord.* — In the shunting yard locomotives are used to close the wagons up when necessary.

The Company is testing road tractors of small size running on macadam pathways arranged between the tracks.

*Midi.* — Powerful locomotives on the fan of shunting sidings.

On the lines of the different yards electric capstans and petrol tractors.

*State.* — Use of locomotives only. Are carrying out tests with the Bauche tractors.

*Paris, Lyons and Mediterranean.* — Most of the fans have only 4.10 to 4.20 m. (13 ft. 5 1/2 in. to 13 ft. 9 3/8 in.) between the centres of the tracks, and it has therefore not been possible to consider the use of tractors for clearing the leading in end of the fans.

II. — *Give a brief description of the methods used, their characteristics and indicate the possibility of using them according to the layout of the yard.*

*Alsace-Lorraine.* —

*Est.* — Road tractors (Bauche or Fordson) have petrol motors (Bauche) or paraffin (Fordson), are of 15 to 20 H. P., 2 speeds forward 2.5 and 5.5 and a reverse speed 5.5. The starting tractive effort, 1 500 kgr. (3 300 lb.), rubber tyred wheels — with a non-skid arrangement for snow.

The capstans exercise a starting effort

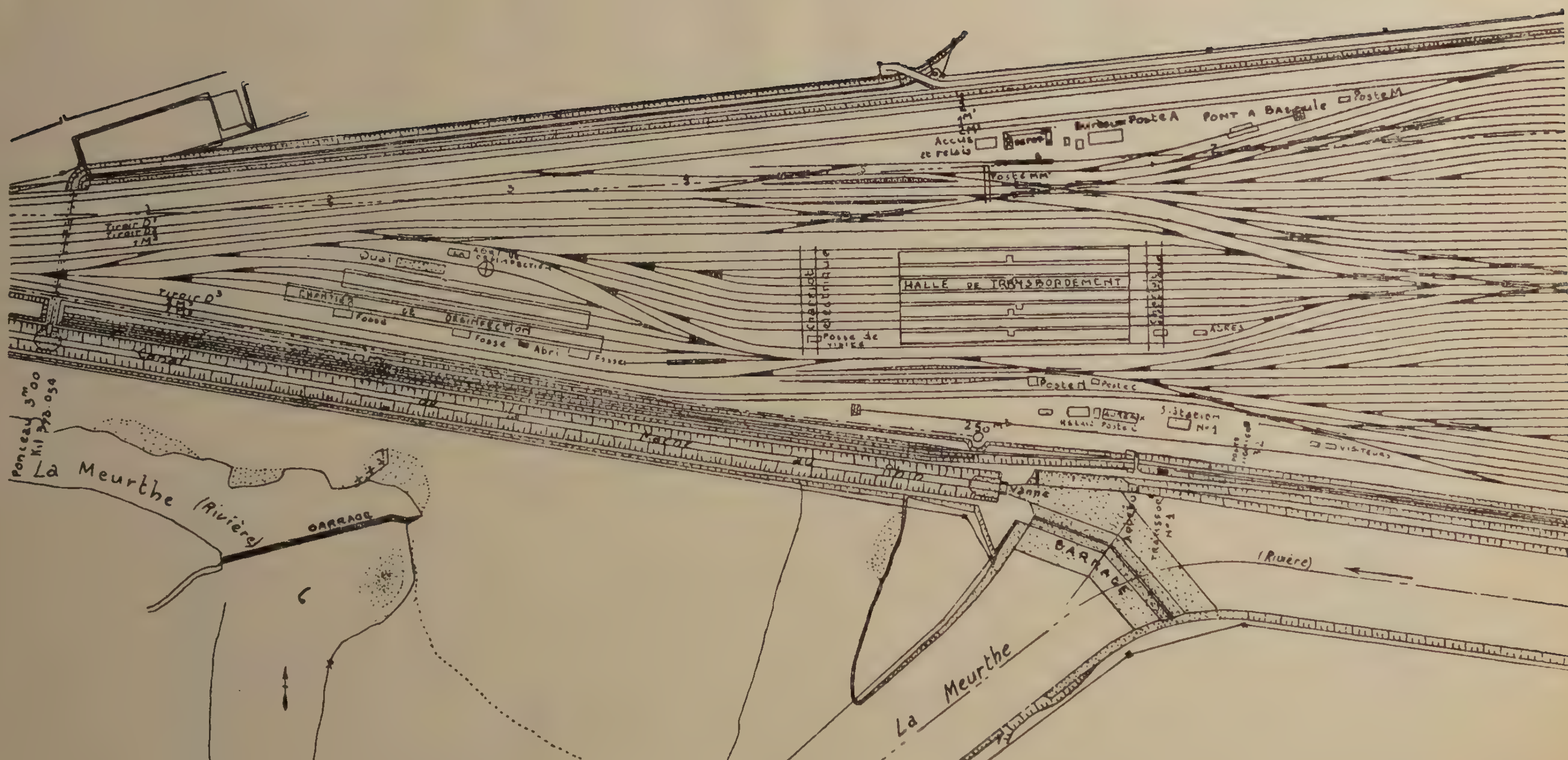



Fig. 12. — Blainville Shunting Yard. — Transhipping installations.

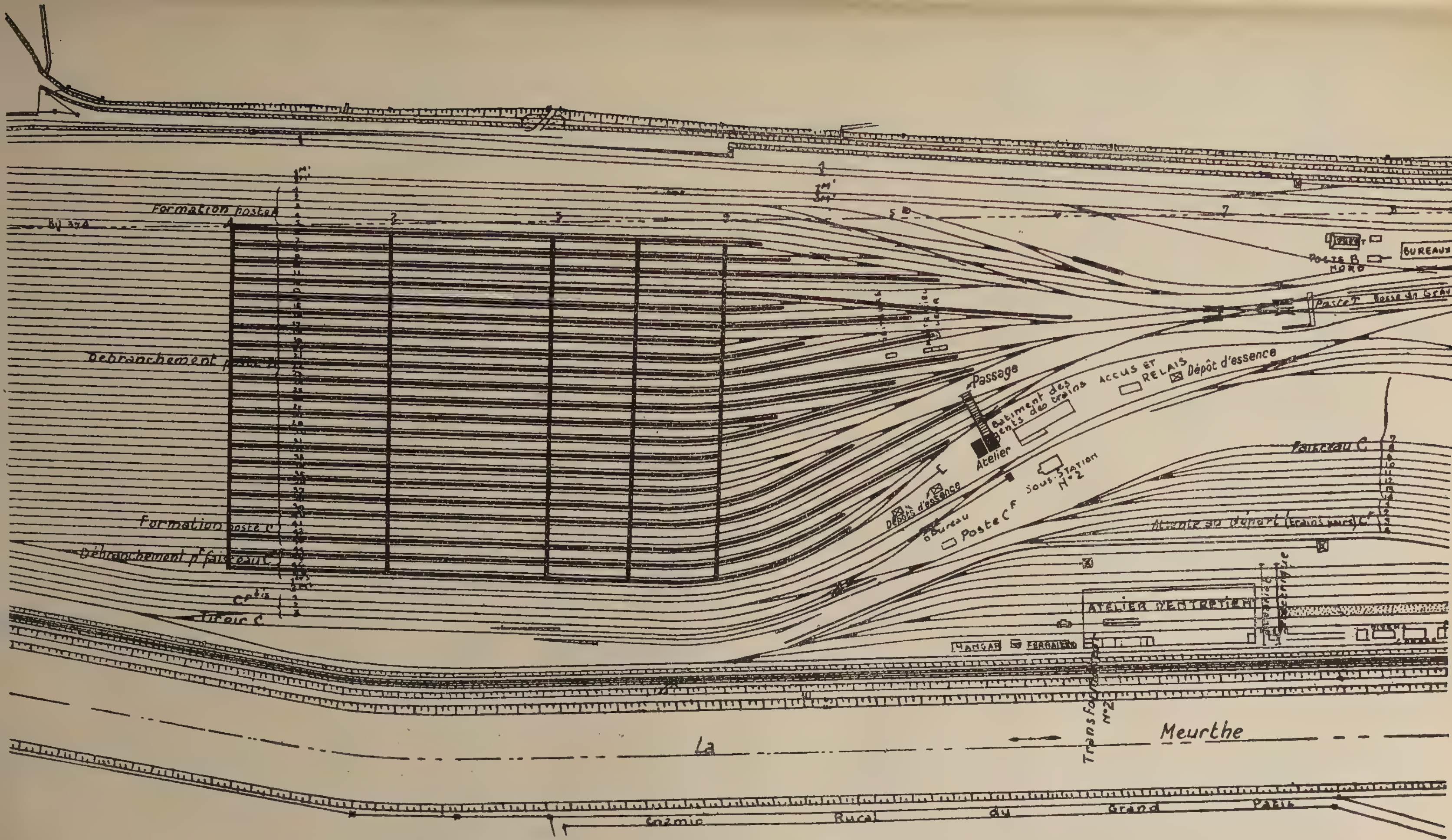



Fig. 13. — Blainville Marshalling Yard. — Shunting sidings. Arrangements made in view of the use of tractors

of 2 000 kgr. (4 400 lb.) or 1 200 kgr. (2 640 lb.) according to the types. Their power is 4 to 4.5 kw.

The electric traversers are 10.50 m. (34 ft. 5 in.) long. They can haul a rake of 600 tons.

*Nord.* — Nothing.

*Midi.* — Bauche tractors (same dimensions as those mentioned above for the *Est*).

Electric capstans of a power of 10 kw., with a braking effort of 1 200 kgr. (2 640 lb.).

III. — *Indicate for each type of appliance, firstly the cost of installation, of upkeep, and of operating; secondly the number of staff employed on the work.*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — Each tractor costs about 50 000 francs. One or two are used during each turn in which shunting is done, according to the size of the fan and the number of wagons shunted off. Each tractor is worked by a driver with a man for handling the ropes. The maintenance is covered by a fitter who has a small shop with a stock of spare parts (fig. 13).

The tractors can only work satisfactorily provided the pathways are sufficiently solid to prevent the wheels sinking into the ground. The paths are built up of old sleepers covered with ballast.

The capstans cost from 10 to 11 000 fr., and the electric traverser truck 150 000 francs.

*Nord.* — No experience.

*Midi.* — Bauche tractors — same results as on the Est.

Electric capstans : price from 11 to 13 000 francs. The costs of maintenance are considerable, especially for the supply and maintenance of rope : cost per capstan 6 000 francs approximately.

IV. — *Results obtained upon the output of the different yards. Savings effected.*

**Replies.**

*Alsace-Lorraine.* —

*Est.* — The annual cost can be calculated for 16 hours shunting at about 400 000 francs.

The annual savings are about 900 000 francs.

The saving effected is therefore 500 000 francs annually.

The output of the shunting yard has been increased by 50 % at least — that of the formation yard by 11 %.

*Nord.* — No experience yet.

*Midi.* — Under good conditions the savings resulting from the use of capstans or electric traversers can be calculated at 25 % approximately of the cost if men or horses were used.

The use of Bauche tractors has also made it possible to effect in the different yards savings of varying amounts, but which are very substantial, and in addition to speed up shunting.

# Detailed questionnaire relating to Question X and replies received from the Italian, Spanish and Portuguese Railways [1].

## SECTION I.

**General arrangements in shunting yards as regards the propulsion and movement of the wagons.**

I. — *What are the methods used for propelling the wagons (propelling by locomotives, propelling by gravity humps or by continuous down gradient)?*

**Replies.**

*Italian State.* — Shunting humps at Turin, Mestre, Alessandria, Bologna and Lambrate Sinistamento (this latter under construction).

— Continuous gradient at Novi-Bovo.

— Other places : shunting by means of locomotives.

*North of Spain.* — Hump and locomotives.

*Portugal.* — Hump.

II. — *Particulars of the gravity hump or of the continuous gradient (gradients, lengths), Particulars of the fan of shunting sidings.*

**Replies.**

*Italian State.* — See profiles given below (fig. 14).

— Shunting sidings on a slope of 1.5 per 1 000 (1 in 666) at Lambrate Sinistamento, on the level elsewhere.

— Length of the shunting sidings 400 to 700 m. (1 312 to 2 296 feet).

*North of Spain.* — See below the gradient section of the station at Las Matas and its hump (figs. 15-16).

*Portugal.* —

III. — *Is the area occupied by the points leading into the shunting sidings and the shunting lines themselves on a slope?*

*What is the length of the area occupied by the points?*

*Arrangements used to facilitate the running of the wagons into them.*

**Replies.**

*Italian State.* — Zone of the points on a slope of 5/1 000 (1 in 200) except at Lambrate Sinistamento where it is on the level.

— Length varying from 120 to 200 m. (494 to 656 feet).

*North of Spain.* — Zone of points on varying gradients (4/1 000 (1 in 250) at Las Matas). Less steep gradients for the shunting sidings.

— Length of the zone of the points : 200 to 300 m. (656 to 984 feet).

*Portugal.* — No.

180 m. (590 feet).

None.

## SECTION II.

**Methods to be used to regulate the speed of the vehicles when shunted off.**

I. — *Do you use any appliances to regulate the speed of the vehicles shunted off?*

**Replies.**

*Italian State.* — Yes.

*North of Spain.* — Slipper brakes placed by hand.

*Portugal.* — Slipper brakes to stop the vehicles.

---

(1) See below the list of administrations not possessing shunting yards nor appliances of interest.

## Longitudinal Section.

**1. Turin and Mestre :**
Present gravity hump.

**2. Alessandria and Bologna :**
Present gravity hump.

**3. Novi S. Bovo :**
Present continuous down gradient.

**4. Lambrate Sinistamento :**
Hump under construction.

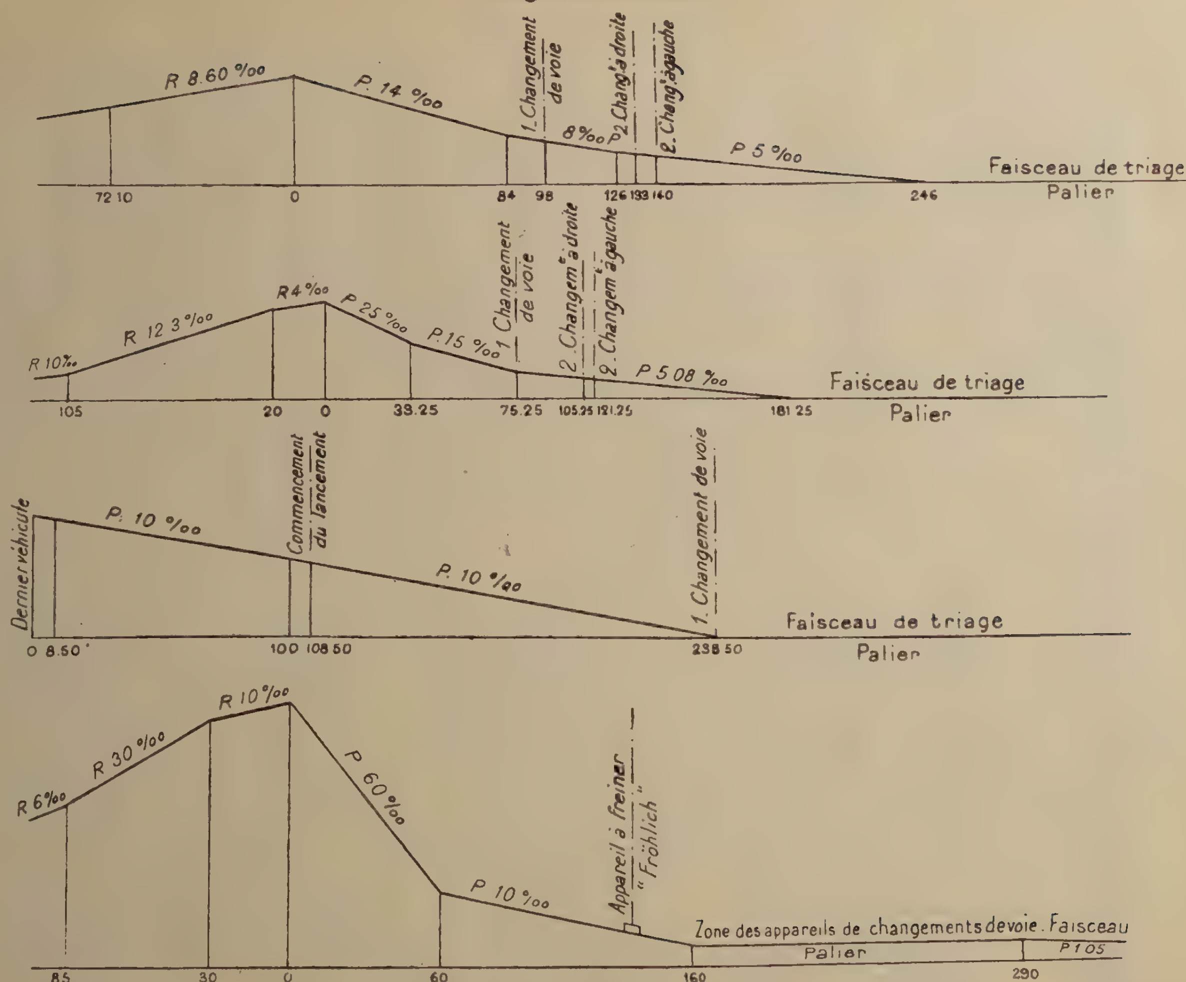



Fig. 14.

*Explanation of French terms :*

**Appareil à freiner » Frölich » = Frölich rail brake. — Changement de voie = Points. — Dernier véhicule = Last vehicle. — Commencement**

II. — *What are these appliances? Are they operated at the site, or from a distance?*

*Give particulars of the system briefly, with a diagram.*

*Mention the materials used, especially on those parts the friction of which causes the reduction of speed.*

**Replies.**

*Italian State.* — Slipper brakes placed by hand. — At Lambrate Sinistamento arrangements are being made to install brakes (Frölich or car retarders).

*North of Spain.* — Slipper brakes operable from a distance are under consideration.

*Portugal.* —

III. — *Theoretical considerations upon the braking effect and upon the output of such appliances.*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

IV. — *Give by class of appliance the first cost, the cost of maintenance and the cost of operating, and in particular the number of staff required to work each.*

**Replies.**

*Italian State.* —

*North of Spain.* — 1 man for 3 of 4 tracks.

*Portugal.* —

V. — *Methods to obtain a rational use of the appliances. Do you use them systematically or only in isolated*

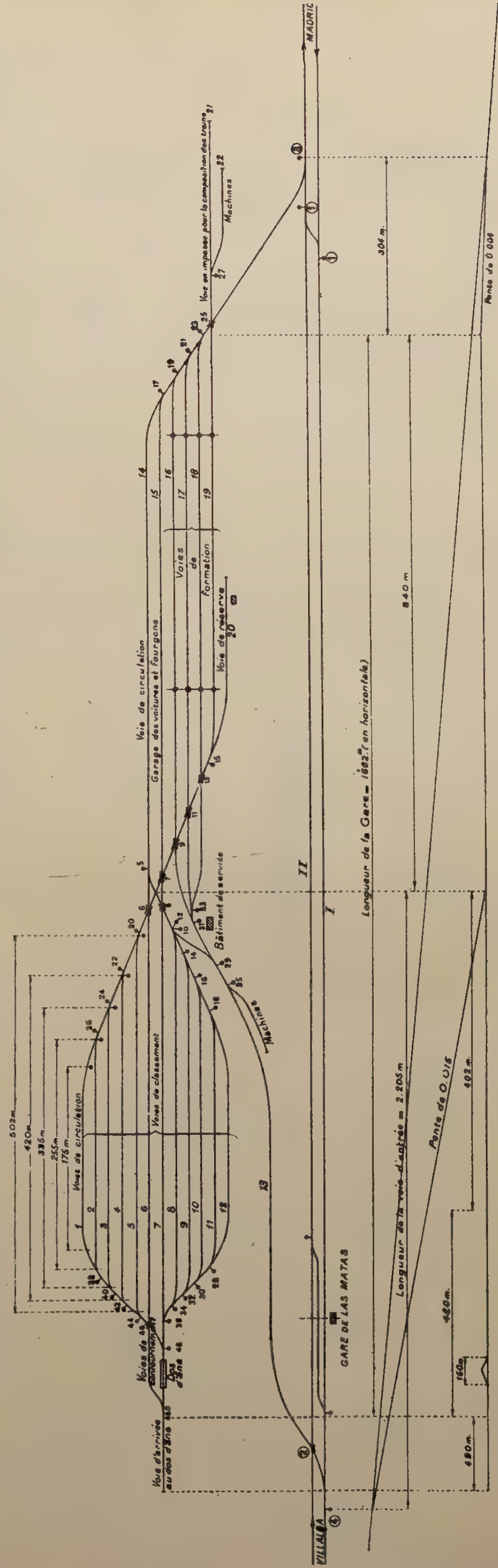



Fig. 15. — Las Matas Marshalling Yard.

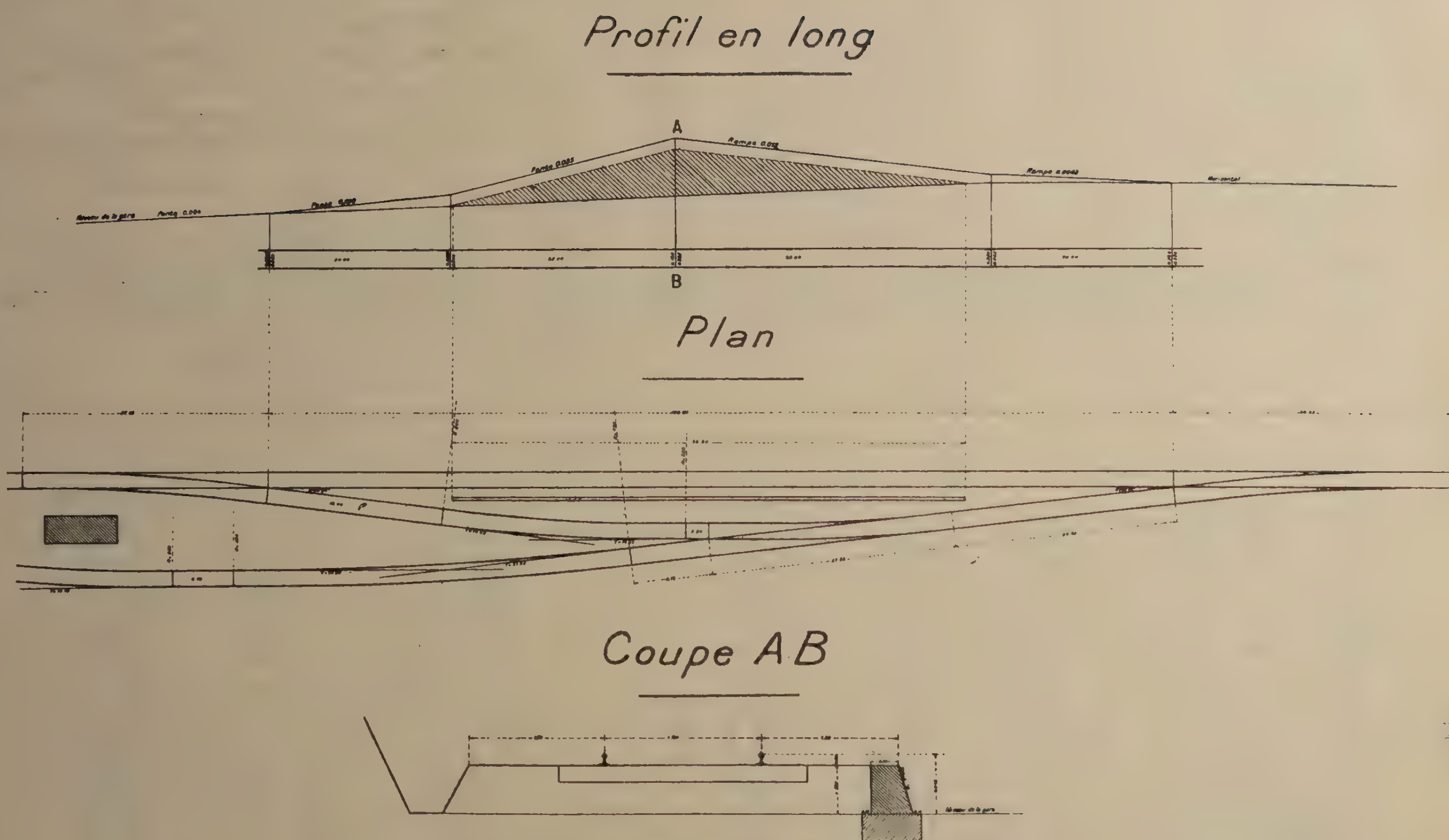



Fig. 16. — Las Matas Marshalling Yard. — Details of the hump.

*Explanation of French terms* : Profil en long – Longitudinal Section. — Coupe AB = Section AB.

*cases? What communications exist between the other men in the yard and those responsible for operating the appliances and especially how are the men kept informed of the work to be done?*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

VI. — *Do you use a single complete appliance :*

a) *for each siding;*

b) *for a group of sidings;*

c) *for the whole of the sidings of the yard.*

**Replies.**

*Italian State.* — At Lambrate Sinistamento provision has been made to install two sets of equipment, one on each half of the fan of shunting sidings.

*North of Spain.* —

*Portugal.* —

VII. — *Does the complete arrangement consist of a single appliance or of several?*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

VIII. — *Location of the appliances :*

a) *just below the gravity hump, — what distance from the end of the gradient?*

b) *on the sidings, — at what distance from the points?*

c) *on a slope, or on the level? Indicate the arrangements adopted for the most complete installation in use.*

**Replies.**

*Italian State.* — At Lambrate just below the hump at the end of the slope of 1 in 100.

*North of Spain.* —

*Portugal.* —

IX. — *Do you brake :*

a) *only the leading wheels of the vehicles?*

b) *all the wheels of the vehicles at the same time?*

c) *one after the other, all the wheels of the vehicles?*

d) *simultaneously the two wheels of a single axle?*

**Replies.**

*Italian State.* — Every pair of wheels and both wheels at the same time will be braked.

*North of Spain.* —

*Portugal.* —

X. — *How do you brake, by means of the track brake, groups of vehicles? How many vehicles may there be in a single rake?*

*How do you brake two following brakes?*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

XI. — *Is the braking controlled independently of the operation of the points? Why?*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

XII. — *What results have you obtained?*

a) *Keeping the best intervals between the vehicles shunted off, and the repercussion of the methods used for reducing the speed of shunting;*

b) *Conditions of stopping the vehicle without harmful shock upon its siding whilst utilising to the best advantage the length of this siding. The length of the zone to be kept clear on the siding in order to make sure of stopping the wagons according to the size of the rakes shunted off;*

c) *Possible harmful effects of checking the speed upon the vehicles.*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

XIII. — *As a result of the use of braking appliances, has the shunting been increased, and by how many wagons per 24 hours?*

*Has there been a reduction in the damages done when shunting?*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

XIV. — *Saving in staff as the result of using mechanical appliances.*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

XV. — *General considerations. Advantages and drawbacks that led you to adopt this or that arrangement.*

**Replies.**

*Italian State.* —

*North of Spain.* —

*Portugal.* —

## CHAPTER III.

**Measures intended to assure the movement of the wagons on the sidings in the different yards.**

I. — *What methods do you use to move the wagons on the sidings in the different yards :*

a) *Gravity;*

b) *Use of mechanical means (locomotives, tractors, capstans, ropes, motors, traversers, transporters?*

**Replies.**

*Italian State.* — Locomotives, capstans, traversers, shunting poles on the locomotives with pulleys or hooks attached to the rails.

*North of Spain.* — Hump and locomotive.

*Portugal.* — a) Yes.

b) Locomotives when the effect of gravity is neutralised by very heavy winds.

II. — *Give a brief description of the methods used, their characteristics, and indicate the possibility of using them according to the layout of the yard.*

*Italian State.* — 1. Shunting locomotive.

2. Vertical capstans 52 cm. (1 ft. 8 1/2 in.) high, maximum diameter 75 cm. (2 ft. 5 1/2 in.), minimum 38 cm. (1 ft. 2 5/16 in.); some of a power of 1 800 kgr. (3 970 lb.) with a maximum speed of 1.15 m. (3 ft. 9 1/4 in.), the others of 1 200 kgr. (2 640 lb.) with a maximum speed of 1 m. (3 ft. 3 3/8 in.).

3. Electric traversers.

*North of Spain.* — The wagons are pushed over the hump by a locomotive, another locomotive sets them back for coupling after shunting in order to form the trains or to work them to the other yards.

*Portugal.* —

III. — *Indicate for each type of appliance, firstly the cost of installation, of upkeep and of operating; secondly the number of staff employed on the work.*

**Replies.**

*Italian State.* — Cost of installing a capstan with 5 pulleys about 50 000 lires. Cost of ropes varies.

Staff required : 2 men.
The price of the traversers varies.
Staff required : 3 men.

*North of Spain.* —

*Portugal.* —

IV. — *Results obtained upon the output of the different yards. Savings effected.*

*Italian State.* —

*North of Spain.* —

*Portugal.* —

*Note.* — The following Administrations state that they have no shunting yards or appliances answering the questions laid down.

Réunion Railways.

Konakry to the Niger Railway.

Gafsa Railway (Tunis).

Thiès to the Niger Railway.

Tunisian Railway Company.

Smyrna to Cassaba Railway.

Indo-China and the Yunnan Railways.

Damas-Hama Railways.

Djibouti to Addis-Abeba Railways.

Algerian Lines of the State.

Dahomey Railway.

South East of France Railways.

Tarn Department Railway (France).

Société des Transports en Commun de la Région parisienne.

Cambrésis Railway.

Ivory Coast Railway.

Bouches-du-Rhône Departmental Railways and Tramways.

Andalusian Railways.

Catalonian Railways.

Medina del Campo to Zamora and Orense to Vigo Railway.

North of Milan Railway.

Reggio-Emilia Railway.

[ 624 .2 ]

# REPORT No. 3

**(Belgium, France and their Colonies),**

## ON THE QUESTION OF THE INVESTIGATION INTO THE STATIC AND DYNAMIC STRESSES IN RAILWAY BRIDGES (SUBJECT III FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1),

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Figs. 1 to 4, pp. 3121 to 3125.

### I. — General considerations.

The question of the dynamic effects set up by trains passing at speed over railway bridges has been, both in Europe and elsewhere, the object of mathematical and experimental studies, the results of which have been interpreted in different ways by different railways.

In France and Belgium and their colonies, which our enquiry regarding the question of the impact or dynamic effects concerns, this effect is generally allowed for in calculating the parts of railway bridges by adding an impact stress coefficient to the live-load.

This coefficient of stress increment is given by an expression, which for France and her colonies is as follows :

$$1 + \alpha + \beta = 1 + \frac{0.4}{1 + 0.2\,L} + \frac{0.6}{1 + 4\dfrac{P}{S}}$$

where L is the length in metres of the portion of bridge floor, bridge girder or span.

P, the total permanent load which it supports, including its own weight and

S, the total maximum additional load which it may be required to support.

This formula will be referred to later on, when the elastic limits to be assumed for the steel will be discussed.

In Belgium, the National Railway Company uses the following formulæ of the German Railways, which differ according to the mode of laying the track under the railway bridge.

$\varphi = 1.00 + \dfrac{60}{150 + L}$ ballasted track, rails without joints.

$\varphi = 1.11 + \dfrac{56}{144 + L}$ 1. ballasted track, rails with joints.
2. unballasted track, on sleepers, rails without joints.

$\varphi = 1.19 + \dfrac{21}{46 + L}$ 1. unballasted track on sleepers, rails with joints.
2. rails fixed directly on longitudinal sleepers of the main girders, rails without joints.

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(1) Translated from the French.

$\varphi = 1.20 + \frac{17}{28 + L}$ rails fixed directly on longitudinal sleepers of the main girders, rails without joints.

L = span of railway bridge. For double-track railway bridges L becomes 2L.

For type 37 steel, the maximum elastic limit under the main stresses varies from 14 to 15 kgr. per mm² (8.89 to 9.52 Engl. tons per sq. inch); this limit varies from 16 to 17 kgr. per mm² (10.16 to 10.79 Engl. tons per sq. inch) if all the stresses are taken into account.

It will be seen further on that actually the French and German formulæ lead to the same results.

The Bas-Congo-Katanga Company have adopted the following impact formula for the calculation of their railway bridges:

$I = 1 + K.$

$K = \frac{10}{10 + L}$ for the main girders,

and $K = 0.9$ for all the girders below the track.

It should be noted that this refers to tracks of 1.067-m. (3 ft. 6 in.) gauge, on which the trains run at a reduced speed.

A comparative study of the two formulæ, the French formula and that of the Bas-Congo-Katanga Company, shows that for small spans, the plotted curves for the two expressions coincide, to diverge slightly afterwards as the span increases, so that for a 60-m. (205 feet) span, the plotted curve of the Bas-Congo-Katanga Company gives an impact 6 to 7 % less than that given by the French formula.

Some railways have not yet laid down any impact formula for calculating their railway bridges and still continue to allow for the dynamic effects by adopting smaller values for the elastic limits of the steel, limits which are not the same for different members of the bridge.

The question naturally arises as to whether the various formulæ which explicitly introduce the dynamic live-load stresses into the calculation do interpret more or less accurately the real impact effects.

In this connexion, let us examine more particularly the French formula, the most recent among those adopted in Europe (England excepted).

This formula was laid down by the Circular of 10 May 1927, the text of which stipulates :

« The dynamic effects due to the shocks of moving loads and to the rapidity with which they intervene, shall be allowed for by increasing the axle-loads of the standard train employed in the calculations. The increment coefficient applicable to a portion of bridge floor, to a girder or to a girder span shall be given by the formula :

$$1 + \alpha + \beta = 1 + \frac{0.4}{1 + 0.2\,L} + \frac{0.6}{1 + 4\frac{P}{S}}$$

in which L represents the length in metres of the said portion of bridge floor, girder or girder span, P, the total permanent load which it supports, including its own weight; S the maximum weight of additional load which it may be required to support in all.

The following are the safe limits for rolled or cast steel.

1. Tension or compression :

$R_1$ = 13 kgr. (8.25 Engl. tons per sq. inch).

$R_2$ = 14 kgr. (8.89 Engl. tons per sq. inch).

2. Slipping or shearing :

$R_1$ = 10 kgr. (6.34 lb. per sq. inch).

$R_2$ = 11.2 kgr. (7.11 Engl. tons per sq. inch).

$R_1$ and $R_2$ being required to satisfy the conditions expressed by the following inequalities :

$$(^1) \qquad c + d + t \leqslant R_1$$
$$c + d + t + v \leqslant R_2$$
$$c + t + w \leqslant R_2$$

It may be useful to recall at this point that the French Regulations of 1915 indirectly allowed for impact in its « conditions of stability ».

The Commission appointed to revise the 1915 Regulations and on whose findings are based the provisions of the 1927 Circular, made the following statement with regard to the dynamic stresses :

« They (the Commission) desire to state in the first place that they do not consider it possible to calculate truly the dynamic effects of moving loads. There are too many causes, that is to say, too many independent variables that are involved in such complex phenomena : nature of the additional loads, the rate at which they come into operation, the nature and state of maintainance of the track, the nature of the bridge members considered, their connections with other members, etc.

It is necessary, therefore, to simplify and to be contented with estimations provided that they are rational, and include the known experimental limits.

With regard to these limits, the Commission admit that the increment coefficient may vary between 1 and 2. The second limit is greater than that of 1.73 which appears to result from experiments made on railway bridges and which the 1915 Commission accepted. They consider, however, that these experiments (recording the static flexures and vibrations) only refer to the main girders and not to the floor members. These latter should be dealt with more strictly and in point of fact the 1915 Commission themselves increased to 2 the increment coefficient to be applied to the said floor members, by introducing considerations of irregular axles, or exceptional vehicles. »

The Commission, inspired by the general results provided by the theory of impact effects on prismatic members, came to the conclusion that consideration must be given on the one hand to the conditions under which the additional loads are applied, above all the rapidity with which they are applied compared with the vibration period, and on the other to the ratio of the impacting and impacted masses.

As regards the first consideration, the Commission believed that the most important parameter was the length L either of the floor member or girder. The ratio $\frac{P}{S}$ of the impacted mass P and the impacting mass S satisfies the second consideration.

For a very short and light member L and $\frac{P}{S}$ being negligible, the increment coefficient may attain the theoretical value of 2. For a main girder with a span of 100 m. (328 ft. 1 in.), assuming $\frac{P}{S}$ equal to unity, the coefficient drops to 1.14.

The Commission, in their report, state that without doubt, to be more accurate, distinct formulæ should be used with different coefficients for each type of bridge (ballasted or unballasted track) but they have not thought it possible to proceed on these lines, « considering on

(1) $c$ = stress under the permanent load.
$d$ = stress under the load increased according to the impact formula.
$v$ = stress due to the action of wind at 150 kgr.
$w$ = stress due to the action of wind at 250 kgr.
$t$ = stress due to the temperature.

the one hand that it was undoubtedly illusory to aim at anything but estimations, at least in the absence of more precise experimental data, and considering on the other hand, that the term $\beta$ in the formula proposed, by introducing the ratio of permanent load and additional load, already took into account sufficiently the variable conditions under which railway tracks are laid ».

Mr. Robert Levi, civil engineer, in his article on the regulations of 10 May 1927 relating to the calculation and testing of steel bridges, makes the following statement :

The lack of any exact experimental work does not allow one to judge of the absolute accuracy of the laws governing the variation of the terms $\alpha$ and $\beta$ with the parameters L and $\frac{P}{S}$, but their hyperbolic shape, which moreover is fairly satisfactory for the mind, because it can readily be conceived that the dynamic increment will decrease rapidly on passing from a short and light member to a longer and more loaded member, is quite in agreement with the results of both theoretical and experimental work on impact. It is true that this work dealt with similar members loaded similarly, whereas the formula of the new regulations makes no distinction between the main girders of a bridge and the members of its floor, which are under rather dissimilar conditions; the dynamic phenomena set up in a bridge member subject to a load applied transversely and with a rapidity depending upon the distance from the next bridge member, must therefore differ from those produced in a main girder subject to an additional load applied longitudinally. At the same time, the present position of the experimental and theoretical work does not allow of the introduction of this difference into the regulation formulæ, and it may be considered that those of the 1927 Regulations, which do not pretend to formulate the exact expressions for the true dynamic stress increments, and which have the merit of simplicity, include the formulæ to which an intense study of the different types of members might lead, with a greater or lesser margin.

From the above, it is quite clear, therefore, that the French 1927 formula, which is the most recent to be adopted by the European railways (England excepted) leaves very serious doubts as to the exactitude of the dynamic effects which it is intended to interpret.

This uncertainty as to the intrinsic value of the numerous impact formulæ, which have made their appearance in recent years, led the International Railway Union to formulate in its programme of investigations and study, the question : « International tests for ascertaining and studying the dynamic effects of rolling stock on steel bridges with the view of developing the international traffic of high capacity wagons. »

This question necessarily implies the eventual revision of the impact formulæ in force.

The Sub-Commission appointed to carry out these tests and this study first of all conducted an enquiry into the state of progress of the research and work on impact carried out by the different railways who are members of the International Railway Union.

This enquiry led to the following main conclusions :

1. No railway had carried out any systematic tests on railway bridges to verify the exactitude of the impact formulæ used. In England, however, the « Stresses in Railway Bridges Committee » was continuing its work.

2. While some railways had made mea-

surements of the dynamic effects, it was not possible to draw any definite conclusions from the results.

3. The uncertainty as to the real value of the impact effects found, was due to the imperfect nature of the recording instruments employed.

4. It was necessary to make a systematic analysis of the possible causes of impact, to isolate them, if possible, and to record their effects.

Continuing its study, the sub-commission drew up a general programme of systematic tests to be carried out by several railways, each making itself responsible for part of the work which the programme involved.

The impact depends upon a large number of factors which are functions of the fundamental structure and the state of the framework of the railway bridge, the type and the state of the track, the type and the state of the rolling stock, and the speed of the traffic on the structure. There is complete discrepancy in the interpretation of the principal causes of impact. Some attribute the essential part to the state of the track, others on the contrary consider that the main element arises from the rolling stock and the speed. In order to clear up the situation, the programme of tests has been drawn up in such a fashion as to enable the dynamic effects to be recorded, which the essential causes giving rise to impact individually provoke in the various types of railway bridges of all spans.

There has been a delay in carrying this programme into effect, owing to the necessity of solving beforehand the problem of satisfactory recording instruments for the dynamic effects, a problem which now appears to be solved.

Naturally, the faithful recording of the dynamic effects is only one part of the problem, the mathematical analysis constitutes another part.

In order that the solution may be complete it is necessary, taking into account the steel floors acting as dynamometers, that the mathematical and experimental results should agree.

This mathematical study of the possible causes of impact is discussed later in this Report, and it is believed that the conclusions arising out of this study are such as to shed more light on this so complex problem of dynamic effects.

The mathematical results obtained by considering modern steam locomotives as are used on railways appear to justify the conclusion that the impact which these locomotives provoke on the main girders of railway bridges is not of extremely great importance. This importance is undoubtedly still less as regards electric locomotives running at speed over the bridge for, theoretically, from the point of view of the counterbalancing, they are superior to steam locomotives. This superiority has not altered materially, however, since the experiments made in 1917 by the Swiss Federal Railways. Electric locomotives and well-balanced steam locomotives have been subjected to comparative dynamic tests; the recorded results have not justified the conclusion that from the point of view of impact one type of locomotive is superior to the other.

On the other hand, the shock effect at the rail joint may be entirely eliminated. For this purpose, it is merely sufficient to place the joints clear of the bridge; for small spans this is an extremely simple matter by using fairly long rails. For moderate and large spans, the solution of the problem lies in welding the rails.

In this connection, reference may be made to the recent decision on the part of the Netherlands Railways to weld the

rails on the Moerdyk bridge (Paris-Amsterdam line). The rails will be welded so as to form continuous lengths of about 210 m. (689 feet) and the joints, provided with expansion devices, will be placed on the piles and the abutments of the structure.

If, therefore, the stresses due to speed and balance weights, as analysed mathematically, and the shock at the rail joints, which is easily eliminated, are taken into account, the increments for the static additional loads prescribed by the impact formulæ in force appear to be too great for girders of moderate or large span.

Does this conclusion, which has been deduced from the mathematical analysis, still apply if the other factors are introduced, which have not been analysed mathematically, and whose effect can only be revealed by direct recording?

If, for the time being, the important work carried out by the English « Stresses in Railway Bridges Committee », is ignored, are there any available experimental data or authoritative opinions which may enable the question to be answered?

The experiments on the direct measurement of dynamic effects, recently carried out by the French Nord Railway Company on several bridge floors system Douai and Leforest have only resulted in general conclusions which are not very definite. These tests were made at different speeds 10 to 120 km. (6.2 to 74.6 miles) per hour, on steel bridge floors of about 4-m., 9-m., 12-m., 30-m., 40-m. (13 ft. 1 1/2 in., 29 ft. 6 3/8 in., 39 ft. 4 1/2 in., 98 ft. 5 1/8 in. and 131 ft. 2 3/4 in.) span, by means of the Feriday-Palmer photographic recording tensometer. The tests appear to show that in a rough fashion at maximum speed, the dynamic coefficient may vary from about 2 to 1.2 for spans varying from about 4 m. to 40 m.

This conclusion, therefore, does not provide any answer to the question.

As far as is known, and in the countries which the present investigations concern, no other important test has been made.

Looking elsewhere, very valuable information has been found in some very recent work by Mr. Bühler, Chief Engineer of the Bridges Departement of the Swiss Federal Railways, on the comparison of the impact as deduced from the regulations in force on different railways (impact formulæ), with the results obtained during the period load tests on the bridges of the Swiss Railways.

The experimental curves were constructed by plotting the flexure generally in the centre of the span) obtained by means of a recording deflectometer; only those diagrams were used, which contained no inaccuracy. The speed was progressive, varying in multiples of 15 km. per hour to reach a maximum of 90 km. (56 miles) per hour.

The impact curves obtained for spans of about 15 to 90 m. (49 ft. 2 1/2 in. to 295 ft. 3 3/8 in.) give ordinates, that is to say, impact coefficients which are much less than those deduced from the formulæ in force, the French formula in particular.

It should be pointed out, however, that the flexures only give the general average impact because they represent the sum of the deformations of a system.

Mr. Bühler, in addition, states that, according to the recorded experimental results, the impact does not vary much for different bridge systems; even the ballasted track does not appear to play an important part.

The Railways in Russia (U. R. S. S.) have for some years been carrying out tests on the impact caused in their railway bridges by their rolling stock. It is not intended to explain here the new

Russian theory leading to the substitution of the comparison of isolated ordinates of an experimental curve and a theoretical curve, by a comparison of the experimental and theoretical surfaces of influence. A second coefficient, called the coefficient of deformation of influence diagram contours is introduced. It may be remarked that this new theory aims more particularly at diagnosing the state of an existing structure, and does not give any definite information regarding the calculation of the members of new railway bridges, yet to be built.

Nevertheless, mention may be made of the result obtained by the Russian railways regarding the relatively insignificant importance of the coefficient of dynamic load on railway bridges, if the rail is perfectly joined and smooth.

Finally, the experiments made by the English « Stresses in Railway Bridges Committee » — which is dealt with more particularly later on in this Report — appear also to confirm that to a large degree the impact deduced from the formulae in force on the Continent takes into account the actual state of affairs.

## II. — Brief study of the vibratory state of a girder on two supports.

This theoretical study was made for the first time in a complete manner before the war by Professor Timoshenko, of Kieff University, who is now in America. He examined in turn the cases for a uniform moving load, a constant moving isolated load, and a sinusoidal moving isolated load. The study of the two lastmentioned cases determines what Professor Hort of Berlin University has called the Timoshenko *speed* effect and counter *balance* effect. Since that time Professor Inglis of Cambridge during the work carried out by the English " Stresses in Railway Bridges Committee " has taken up the different cases studied by Professor Timoshenko completing them by additional studies involving the introduction of a factor of absorption of the vibrations, and considering also the body of the locomotive as if suspended on springs. From the last consideration, the English committee has, moreover, deduced the existence of two critical speeds, corresponding to springs in a *locked* state or *unlocked* state.

While giving full due to the great importance of Professor Inglis's work, we cannot disguise the fact that in this matter Professor Timoshenko has really paved the way with mathematical methods of unequalled elegance. It being understood that the analytical results form necessarilly the basis of the practical evaluation of impact, it is believed that interest attaches to the analytical explanation of the different cases given below. The method followed is that of Professor Timoshenko but simplified by restricting the operations to the principal term; in neglecting in this way harmonics greater than 1 — agreeing in this respect with Professor Inglis — the equations become simpler and bring to light at once the most interesting results.

### § 1. — Hypotheses of the calculations.

1. The deformation $y$ is represented by the expression

$$y = qu. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where $u = f(x)$ and $q = \varphi(t)$, $q$ being regarded as an arbitrary parameter.

The vibratory state due to any cause whatsoever may be determined by the Lagrange equation

$$\frac{d}{dt}\left(\frac{\delta T}{\delta q'}\right) - \frac{\delta T}{\delta q} = \frac{\delta U}{\delta q} \quad . \quad . \quad . \quad (2)$$

In this equation, T represents the half of the kinetic energy of the system

$$T = \tfrac{1}{2}\,\Sigma m v^2$$

and $$\frac{\delta U}{\delta q} = \frac{\delta Te}{\delta q} - \frac{\delta Ti}{\delta q}.$$

$Te$ and $Ti$ being the work done by the external and internal forces, respectively.

2. From the expression $y = qu$ we obtain :

$$v = \frac{dy}{dt} = q'u.$$

Assuming that the girder vibrates under a dead weight or a continuous, uniformly distributed load, the expression for the kinetic energy becomes

$$T = \tfrac{1}{2}\,\Sigma mv^2 = \tfrac{1}{2}\, m \int_0^l q'^2 u^2\, dx,$$

$m$ being the mass per unit length,

$$\frac{d}{dt}\frac{\delta T}{\delta q'} = q''\, m \int_0^l u^2\, dx$$

$$\frac{\delta T}{\delta q} = 0.$$

The girder being subject to simple bending.

$$Ti = \frac{1}{2\varepsilon}\int_0^l M^2\, dx$$

$\varepsilon = EI$ (E coefficient of elasticity, I moment of inertia.)

M = bending moment in one point,

$$Ti \text{ becomes } = \frac{\varepsilon}{2}\int_0^l \left(\frac{d^2y}{dx^2}\right)^2 dx$$

and

$$\frac{\delta Ti}{\delta q} = \varepsilon \int_0^l \frac{d^2y}{dx^2} \times \frac{\delta}{\delta q}\left(\frac{d^2y}{dx^2}\right) dx$$

$$\frac{d^2y}{dx^2} = qu''; \frac{\delta}{\delta q}\frac{d^2y}{dx^2} = u''$$

$$\frac{\delta Ti}{\delta q} = \varepsilon q \int_0^l u''^2 dx.$$

The *general Lagrange equation* is transformed into

$$q''\, m \int_0^l u^2 dx + q\varepsilon \int_0^l u''^2\, dx = \frac{\delta Te}{\delta q} \quad . \; . \; (3)$$

The expression $\frac{\delta Te}{\delta q}$ will vary according to each case examined.

3. We shall assume that in $y = qu$, $u$ function of $x$ alone, may be represented by

$$u = \sin \pi \frac{x}{l}.$$

The terms in $u$ entering into the general equation take the form :

$$\int_0^l u^2\, dx = \int_0^l \sin^2 \pi \frac{x}{l}\, dx = \frac{l}{2}$$

$$u' = \frac{\pi}{l}\cos \pi \frac{x}{l},\; u'' = -\frac{\pi^2}{l^2}\sin \pi \frac{x}{l}$$

$$\int_0^l u''^2\, dx = \frac{\pi^4}{2l^3}$$

The general equation finally assumes the form :

$$q'' \cdot \frac{ml}{2} + q\varepsilon \frac{\pi^4}{2l^3} = \frac{\delta Te}{\delta q}.$$

*Finally*

$$q'' + q \cdot \frac{\pi^4}{l^4}\; \frac{\varepsilon}{m} = \frac{2}{lm}\frac{\delta Te}{\delta q}$$

writing $$\alpha = \frac{\pi^2}{l^2}\sqrt{\frac{\Sigma}{m}}$$

$$q'' + \alpha^2 q = \frac{2}{lm}\frac{\delta Te}{\delta q} \quad . \; . \; . \quad (4)$$

### § 2. — Examination of the different particular cases.

1st CASE. — *Free vibrations under permanent load or continuous uniform live load.*

1. Expression for $\frac{\delta Te}{\delta q}$

$$\delta^2 Te = pdx,\; \delta y = pdxudq$$

$$\delta Te = p\delta q \int_0^l udx$$

$$\frac{\delta Te}{\delta q} = p \int_0^l udx$$

$$\int_0^l u dx = \int_0^l \sin \pi \frac{x}{l} dx = \frac{2l}{\pi}$$

$$\frac{\delta Te}{\delta q} = \frac{2pl}{\pi}.$$

2. *The Lagrange equation becomes*

$$q'' + \alpha^2 q = \frac{4pl}{\pi lm}.$$

Linear equation with constant coefficients, and second constant term of the form

$$q'' + \alpha^2 q = \beta.$$

The general equation is

$$q = \frac{\beta}{\alpha^2}(1 - \cos \alpha t)$$

i. e. $$q = \frac{4}{\pi}\frac{pl^4}{\varepsilon\pi^4}(1 - \cos \alpha t)$$

and $$y = \frac{4}{\pi}\frac{pl^4}{\varepsilon\pi^4}(1 - \cos \alpha t) \sin \pi \frac{x}{l}.$$

3. $q$ and $y$ are periodic functions of $t$, such that T being the period

$$\alpha(t + T) = \alpha t + 2\pi$$

$$T = \frac{2\pi}{\alpha}$$

the frequency $N = \frac{1}{T} = \frac{\alpha}{2\pi}$

$$N = \frac{\pi}{2l^2}\sqrt{\frac{\varepsilon}{m}} \text{ and } T = \frac{2l^2}{\pi}\sqrt{\frac{m}{\varepsilon}}.$$

T is the period of vibration of the free girder or under a *continuous* and *uniform* live load.

If the successive cases of constant isolated loads or of periodic loads acting upon the girder are examined, this period T varies continuously with the position and the magnitude of the loads.

Nevertheless, in practice, the additional dynamic effects are of greatest importance when all the bridge roadway is loaded.

It will suffice, therefore, in the majority of cases, to consider the period of vibration corresponding to the bridge totally loaded.

4 The position of equilibrium is attained for $\cos \alpha t = 0$,

that is $$\alpha t = \frac{\pi}{2},\ t = \frac{\pi}{2\alpha} = \frac{T}{4}$$

$$y = \frac{4}{\pi}\frac{pl^4}{\varepsilon\pi^4}\sin \pi \frac{x}{l} \text{ and for } x = \frac{l}{2},$$

$$\sin \pi \frac{x}{l} = 1$$

$$y = f \text{ static} = \frac{4}{\pi}\frac{pl^4}{\varepsilon\pi^4} \simeq \frac{5}{384}\frac{pl^4}{\varepsilon}$$

corresponding to the flexure calculated by the ordinary method.

The maximum flexure will correspond to the value of $t$, such that

$$\cos \alpha t = -1, \text{ i. e. } \alpha t = \pi$$

$$t = \frac{T}{2}.$$

This maximum dynamic flexure $f = 2 \times f$ static, a result which was already known.

5. *Calculation of the vibration period of the loaded bridge.*

$$T = \frac{2\pi}{\alpha} = \frac{2l^2}{\pi}\sqrt{\frac{p}{\varepsilon g}}.$$

For a completely determined girder, I and $p$ being fixed, T may be calculated for each particular case.

The formula may be simplified considerably by making two additional assumptions :

1. Steel working at a maximum elastic limit of 1 000 kgr/cm² (14 223 lb. per sq. inch) without dynamic increment and
2. constant proportion of the height to the span of the girder.

If $\sigma$ represents the maximum working stress, and $m = \frac{l}{H}$ the proportion of the span to the height of the girder

$$\sigma_{max.} = \frac{Mv}{I} = \frac{pl^2}{8} \times \frac{H}{2I}$$

$$\frac{p}{1} = \frac{16\sigma}{l^2 H} \text{ and } \sqrt{\frac{p}{\varepsilon g}} = \frac{4\sqrt{\sigma}}{l\sqrt{Eg}\sqrt{H}}.$$

*Finally* $\quad T = \frac{8}{\pi}\sqrt{l}\sqrt{m}\sqrt{\sigma} \quad \frac{1}{Eg}$

$$T = K\sqrt{l}$$

or $T^2 = K^2 l$ a parabola of the second degree in T and $l$.

$$K^2 = \frac{64}{\pi^2} m \frac{\sigma}{E} \frac{1}{g}$$

$m = 8$, average proportion of girders.
$\sigma = 10$ kgr./mm²,
$E = 20\ 000$ kgr./mm²,
$g = 9.81$ m /sec.,

$K^2 = \frac{1}{380}$, assuming $K^2 = \frac{1}{400}$, taking into consideration the uncertainty of the factors, we obtain the simple *relationship*

$$T = \frac{\sqrt{l}}{20}$$

under a simple permanent load, $p$ being the permanent load and $q$ the excess load.

$$T_{p} + = T_{p+q}\sqrt{\frac{p}{p+q}}.$$

In fact the coefficient *20* ought to be increased; a value of *25* to *30* ought to be taken into consideration.

2nd CASE. — *Vibration under a constant isolated load P moving with a constant velocity of translation V.*

1. Expression for

$$\frac{\delta Te}{\delta q}$$

$$\delta Te = P\delta y = Pu\delta q.$$

$$\frac{\delta Te}{\delta q} = (Pu)\,x = Vt.$$

The Lagrange equation becomes

$$q'' + \alpha^2 q = \frac{2}{lm} Pu = \frac{2P}{lm} \sin \frac{\pi V t}{l}$$

of the type

$$q'' + \alpha^2 q = \beta \sin \gamma t$$

where

$$\beta = \frac{2P}{lm} \text{ and } \gamma = \frac{\pi V}{l}.$$

Integral $\quad q = \frac{\beta}{\alpha^2 \gamma^2}\left(\sin \gamma t - \frac{\gamma}{\alpha} \sin \alpha t\right).$

writing

$\frac{2l}{V} = T_1, \qquad$ T being still $T = \frac{2\pi}{\alpha}$

$$\gamma = \frac{2\pi}{T_1},\ \alpha = \frac{2\pi}{T},\ \frac{\gamma}{\alpha} = \frac{T}{T_1}.$$

2. The equation for the vibratory state becomes:

$$q = \frac{2P}{lm\,(\alpha^2 - \gamma^2)}\left(\sin 2\pi \frac{t}{T_1} - \frac{T}{T_1} \sin 2\pi \frac{t}{T}\right)$$

and $\qquad y = q \times \sin \pi \frac{x}{l}$

If we suppose $x = \frac{l}{2}$, the middle of the girder, and $V = 0$, corresponding static state for $t = \frac{T_1}{4}$

$$f \text{ static} = \frac{2P}{lm\alpha^2} = \frac{2Pl^3}{\varepsilon\pi^4} \approx \frac{1}{48}\frac{Pl^3}{\varepsilon},$$

the result of the ordinary theory.

3. The expression for $y$ indicates that $y$ is made up of two terms, one arising out of the forced vibration of the girder under the passage of the load — period $T_1$ — the other arising out of the natural vibration — period T — multiplied by the ratio $\frac{T}{T_1}$.

Resonance would be attained for

$$\alpha^2 = \gamma^2,\ T = T_1.$$

In this case $y$ would assume the form $\frac{0}{0}$; its true value would be obtained by applying the L'Hopital rule.

In practice, as we shall see by means of numerical values, $T_1$ is always much greater than T, the critical speed would not be reached and the effect due to the speed alone is always considerably reduced.

4. By introducing the value of $\alpha$ into the expression for $y$, the expression becomes

$$y = \frac{2Pl^3}{\pi^4 \varepsilon} \frac{1}{1 - \left(\frac{\gamma}{\alpha}\right)^2} \sin \frac{\pi x}{l} \left(\sin 2\pi \frac{t}{T_1} - \frac{T}{T_1} \sin 2\pi \frac{t}{T}\right).$$

Similarly, the value for the *bending moment* would assume the form

$$M = \frac{2Pl}{\pi^2} \frac{1}{1 - \left(\frac{\gamma}{\alpha}\right)^2} \sin \frac{\pi x}{l} \left[\sin 2\pi \frac{t}{T_1} - \frac{\gamma}{\alpha} \sin 2\pi \frac{t}{T}\right].$$

For $V = 0$ giving $\gamma = 0$, the expressions for $y$ and for M are those for the lines of force of the deformation and of M in the point $x$.

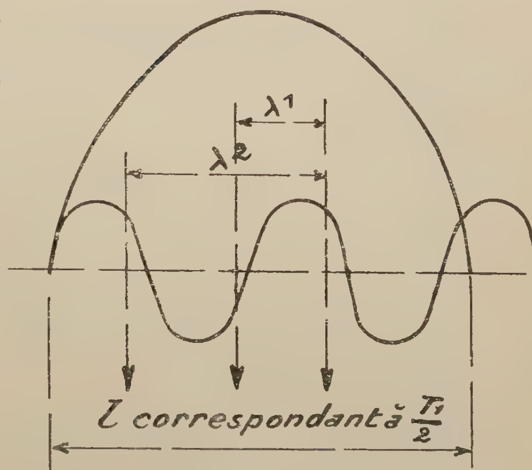
In the case where a *train of forces* has to be considered, the expressions in $y$ and M would contain a series of terms in

$$t \cdot t_1 \cdot t_2 \ldots t_1 = t - \frac{\lambda_1}{V};\ \ t_2 = t - \frac{\lambda_2}{V}$$

if $\lambda^1$, $\lambda^2$, etc., are the distances of the 2nd, 3rd forces... from the first, V being the speed at which the load passes along the girder.

*Graphically*, the influence of a train of forces on a girder may be studied by plotting the two sinusoidals in

$$2\pi \frac{t}{T_1} \text{ and } 2\pi \frac{t}{T}.$$




*Explanation of French terms*:
$l$ correspondant à $\frac{T_1}{2}$ = $l$ corresponding to $\frac{T_1}{2}$.

In order to determine approximately the *effect of the speed* of a given train, the train is placed on the girder in the *most unfavourable static position* and by measuring the + and — ordinates, the individual effect pertaining to each force is evaluated.

It will be seen at once that, if the bridge is long enough to enable a train of numerous forces to take up a position, the sum of the + and — effects will tend to zero, and that in fact the *speed effect* is very small if not zero in bridges of average or large span.

The condition for the speed effects to be constantly added to one another so as to produce the maximum effects would be

$$T = \frac{\lambda}{V}.$$

where $\lambda$ is the distance between the axles assumed to be equidistant and V is the constant speed of passage.

*Critical speed.* — The critical speed would be that corresponding to

$$T = T_1.$$

*In practice* this speed is never attained.

3rd CASE. — *Vibration under an isolated load periodically moved at a constant speed of translation*

1) The general Lagrange equation is still

$$q'' + \alpha^2 q = \frac{2}{lm}\frac{\delta Te}{\delta q}.$$

The periodic isolated load in question is set up by the free balance-weight, balancing the forces of inertia of the reciprocating parts.

If V is the speed of translation of the wheel, the angular speed $w$ of the wheel would be

$$w = \frac{V}{r}.$$

The corresponding centrifugal force of the balance-weight P will be

$$\frac{P}{g}\frac{V^2}{r}$$

of which the vertical component will be

$$F_\alpha = \frac{P}{g}\frac{V^2}{r}\cos\alpha,$$

$\alpha$ being the angle of the balance-weight with the vertical (downwards).

The periodic vertical component takes the maximum values

$$\pm\frac{P}{g}\frac{V^2}{r}$$

according as the balance-weight is on the rail or at 180° in the vertical position diametrically opposite

$$\frac{\delta Te}{\delta q} = F_\alpha u,$$

$u$ being expressed in $t$,

$$\frac{\delta Te}{\delta q} = F_\alpha \sin\frac{\pi V t}{l} = \frac{P}{g}\frac{V^2}{r}\cos\frac{Vt}{r}\sin\frac{\pi V t}{l}$$

assuming that at the time $t = o$, the balance-weight is on the rail,

$$\alpha = \frac{Vt}{r}.$$

Writing

$$F = \frac{P}{g}\frac{V^2}{r}$$

the Lagrange equation becomes :

$$q'' + \alpha^2 q = \frac{2}{lm} F \cos\frac{Vt}{r}\sin\pi\frac{Vt}{l}.$$

The term

$$2\cos\frac{Vt}{r}\sin\pi\frac{Vt}{l} = \sin\left(\frac{\pi V t}{l} + \frac{Vt}{r}\right) + \sin\left(\frac{\pi V t}{l} - \frac{Vt}{r}\right).$$

Putting

$$\gamma = \frac{\pi V}{l} + \frac{V}{r} \qquad \beta = \frac{F}{lm}$$

$$\delta = \frac{\pi V}{l} - \frac{V}{r}$$

the equation may be written

$$q'' + \alpha^2 q = \beta(\sin\gamma t + \sin\delta t).$$

Its integral is

$$q = K'\left(\sin\gamma t - \frac{\gamma}{\alpha}\sin\alpha t\right) + K''\left(\sin\delta t - \frac{\delta}{\alpha}\sin\alpha t\right)$$

where $K' = \dfrac{\beta}{\alpha^2 - \gamma^2}$ and $K'' = \dfrac{\beta}{\alpha^2 - \delta^2}$.

The value for $q$ is transformed as follows :

$T_1 = \dfrac{2l}{V}$ period of forced vibration of the girder under the action of speed alone.

$T_2 = \dfrac{2\pi r}{V}$, period of rotation of the wheel.

$T = \dfrac{2\pi}{\alpha}$ period of free vibration of the beam.

$$q = \frac{\beta}{\alpha^2 - \gamma^2}\left[\sin 2\pi t\left(\frac{1}{T_1} + \frac{1}{T_2}\right) - \frac{\frac{1}{T_1} + \frac{1}{T_2}}{\frac{1}{T}} \sin 2\pi \frac{t}{T}\right] +$$

$$+ \frac{\beta}{\alpha^2 - \delta^2}\left[\sin 2\pi t\left(\frac{1}{T_1} - \frac{1}{T_2}\right) - \frac{\frac{1}{T_1} - \frac{1}{T_2}}{\frac{1}{T}} \sin 2\pi \frac{t}{T}\right].$$

If N, $N_1$, $N_2$ are the frequencies corresponding to the above-mentioned vibrations, the value of $q$ may also assume the following form :

$$\alpha = 2\pi N, \qquad \gamma = 2\pi(N_1 + N_2), \qquad \delta = 2\pi(N_1 - N_2),$$

$$q = \frac{\beta}{4\pi^2}\left\{\frac{1}{N^2 - (N_1 + N_2)^2}\left[\sin 2\pi t(N_1 + N_2) - \frac{N_1 + N_2}{N} \sin 2\pi N t\right] + \right.$$
$$\left. + \frac{1}{N^2 - (N_1 - N_2)^2}\left[\sin 2\pi t(N_1 - N_2) - \frac{N_1 - N_2}{N} \sin 2\pi N t\right]\right\}.$$

Each of the principal terms of the value of $q$ is made up of two terms, one in $(N_1 + N_2)\,t$ or in $(N_1 - N_2)\,t$ corresponding to the forced vibrations under the load, and the other in $Nt$ corresponding to the free vibration.

2. *Critical speeds* :

$$\text{If } N = N_2 \pm N_1 \begin{cases} N = N_2 + N_1 \\ N = N_2 - N_1 \end{cases}$$

wherein each of the principal terms assumes the form $\frac{0}{0}$; writing for example

$$N_2 + N_1 = xN,$$

the first principal term becomes :

$$\frac{1}{N^2(1 - x^2)}(\sin 2\pi x N t - x \sin 2\pi N t)$$

on applying l'Hopital's rule and simplifying with respect to $x$.

$$\frac{1}{-2xN^2}(\cos 2\pi x N t \times 2\pi N t - \sin 2\pi N t),$$

that is

$$\frac{1}{2N^2}\left(\pi N t \times \cos 2\pi N t + \frac{1}{2}\sin 2\pi N t\right),$$

for $x = 1$.

The term $q$ is therefore increasing in $t$; neglecting the term for the free vibration, and the unaltered terms, the expression for $g$ becomes for the critical speed :

$$q = 2\pi N t \cos 2\pi N t \times \frac{\beta}{4\pi^2 N^2}$$

and $y = \frac{\beta}{4\pi^2 N^2} \sin \frac{\pi x}{l} \times 2\pi N t \cos 2\pi N t$

increasing with $t$.

A first conclusion is imposed which is that there are in fact, supposing that everything takes place according to the assumed hypothesis, two neighbouring and successive *critical speeds* corresponding to the values of

$$\left.\begin{matrix} N = N_2 + N_1 \\ \text{and} \quad N = N_2 - N_1 \end{matrix}\right. \quad \text{i.e.} \quad \left.\begin{matrix} N_2 = N - N_1 \\ N_2 = N + N_1 \end{matrix}\right\}$$

$N_1 = \frac{1}{T_1} = \frac{1}{\frac{2l}{V}}$ will generally be much less than $N = \frac{1}{T}$, the frequency of the free girder.

In fact, $N_2$ will be pratically equal to N and in the usual applications it may be

regarded sufficient to consider *only one critical speed* corresponding to the synchronism between the period of free vibration of the girder and the period of rotation of the wheel.

At the same time this speed is the average speed of a *zone* of two critical speeds.

* * *

In the recent English experiments, two critical speeds were recognised, corresponding to *two* distinct *states of vibration* for the girder :

1. Locomotive springs locked body vibrating with the structure.

2 Unlocked springs, body vibrating freely on the structure.

The first state corresponds to that which we have considered of a fully loaded girder.

The second would rather correspond to that of a girder *without* excess load with a greater critical speed.

It is doubtful whether there is any advantage to be gained in complicating further a problem already rather complicated in itself. It would be still necessary, moreover, to introduce into the equations as has been done by Professor Inglis, a term of extinction (decrement) indicating a gradual decrease of the vibrations.

3. There is another factor, to which up to the present, no one has drawn sufficient attention.

This is the *influence of the distance between the successive axles.*

The problem has constantly been treated as if all the train consisted of *one axle alone.* As a matter of fact, the influence of each axle may be interpreted sinusoidal, the + and — effects being added in interference one with another. Let us suppose that the successive axles are at distances $\lambda$ apart, and that the free balance weight distributed equally among all the successive axles occupies parallel positions on each of them.

Following this assumption, at the time $t$ the successive axles will be out of phase by $\frac{\lambda}{V}, \frac{2\lambda}{V} \ldots \frac{n\lambda}{V}$ corresponding to the second and $(n-1)$th axle.

The expression for $y$ becomes :

$$y = \text{constant term} \times 2\pi N t \times \cos 2\pi N t$$
$$+ 2\pi N\left(t - \frac{\lambda}{V}\right)\cos 2\pi N\left(t - \frac{\lambda}{V}\right)$$
$$+ \ldots\ldots$$
$$+ 2\pi N\left(t - \frac{n\lambda}{V}\right)\cos 2\pi N\left(t - \frac{n\lambda}{V}\right).$$

*In practice, 2, 3, 4 or 5 axles will generally have to be considered.*

If $x$ is the abscissa of the first axle at the time $t$ with respect to the origin of the girder, the successive stresses are proportional to

$$2\pi\frac{t}{T}\cos 2\pi\frac{t}{T} = 2\pi\frac{x}{VT}\cos 2\pi\frac{x}{VT}$$
$$2\pi\left(\frac{t}{V} - \frac{\lambda}{VT}\right)\cos\frac{2\pi}{T}\left(t - \frac{\lambda}{V}\right) =$$
$$= 2\pi\frac{x-\lambda}{VT}\cos 2\pi\frac{x-\lambda}{VT}$$

$VT = VT_2 = 2\pi r$ circumference of the wheel.

$$2\pi\frac{x}{VT}\cos 2\pi\frac{x}{VT} = 2\pi\frac{x}{2\pi r}\cos 2\pi\frac{x}{2\pi r}.$$
$$1^{st}\text{ term} = \frac{x}{r}\cos 2\pi\left(\frac{x}{2\pi r}\right).$$
$$2^{nd}\text{ term} = \frac{x-\lambda}{r}\cos 2\pi\frac{x-\lambda}{2\pi r}.$$
$$\ldots\ldots\ldots\ \frac{x-n\lambda}{r}\cos 2\pi\frac{x-n\lambda}{2\pi r}$$

The force of the different axles may be determined graphically by plotting along the length of the girder successive cosinusoi dals of the length $2\pi r$. These cosinusoidals will represent the line of force

of each of the axles. In order to obtain the true value of the force of each axle, it will still be necessary to multiply each ordinate (cos) by the ratio of the abscissa of the axle to the wheel radius. This is therefore an easy and practical method for determining the forces in question. If the girder is long, the terms

$$\frac{x}{r}, \frac{x-\lambda}{r}, \frac{x \quad n\lambda}{r}$$

will have values differing little, and in fact the force is given by the sum of the cosines :

$$\cos 2\pi \frac{x}{2\pi r}, \cos 2\pi \frac{x-\lambda}{2\pi r} \ldots$$

It may be remarked that the coupled axles, being grouped at the minimum distance $\lambda$, this distance is always practically equal to $\frac{2\pi r}{3}$.

This relationship $\lambda = \frac{2\pi r}{3}$ being realised, we deduce therefrom a *remarkable* and *extremely important* property for certain types of locomotive.

On a bridge of sufficient length for the factors $\frac{x}{r}$, $\frac{x-\lambda}{2r}$ and $\frac{x-2\lambda}{r}$ to differ practically only slightly, merely taking into consideration the combined action of the coupled axles (balance weights distributed equally and parallel to one another), *a locomotive with three coupled axles* would exert *no counterbalance action at all*, at *whatever speed*.

This property may be demonstrated by applying the Fresnel rule on the composition of vibrations; it may also be shown *directly in the folloving manner* :

The successive cosines are:

$$\cos 2\pi \frac{x}{2\pi r} = \cos \frac{x}{r},$$

$$\cos 2\pi \frac{x-\lambda}{2\pi r} = \cos \left(\frac{x}{r} - \frac{2\pi}{3}\right),$$

$$\cos 2\pi \frac{x-2\lambda}{2\pi r} = \cos \left(\frac{x}{r} = \frac{4\pi}{3}\right),$$

$$\Sigma \cos = \cos \frac{x}{r} + 2 \cos \frac{x}{r} \cos \frac{2\pi}{3} = 0.$$

In a locomotive with *two coupled axles*, the two terms are :

$$\cos \frac{x}{r} + \cos \left(\frac{x}{r} - \frac{2\pi}{3}\right)$$

$$= \cos \left(\frac{x}{r} - \frac{\pi}{3}\right)$$

Everything takes place as if the locomotive *had a single axle*, the balance weight being displaced back by $\frac{\pi}{3}$.

In a *locomotive with four axles*, the final result would be the same as that for a locomotive with a single axle.

*On the average* it may be concluded from this analysis that the locomotives with three coupled axles, satisfying the indicated conditions, will give the minimum counterbalance effect. We conclude equally that, for locomotives with four or five axles, it would be preferable not to provide horizontal balance weights except on *only three adjacent axles*.

* * *

The above-mentioned property for groups of *three coupled axles* may be shown by considering directly the *differential equation*.

The *second member* of this equation is written

$$\sin \frac{Vt}{r}\left(\frac{\pi r}{l} + 1\right) + \sin \frac{Vt}{r}\left(\frac{\pi r}{l} - 1\right)$$

for a single axle.

Considering two other axles at distances of $\lambda$ away, corresponding to intervals $\tau = \frac{\lambda}{V}$ these terms may be written

$$\sin\left[\frac{Vt}{r}\left(\frac{\pi r}{l} + 1\right) - \frac{V\tau}{r}\left(\frac{\pi r}{l} + 1\right)\right] +$$

$$+ \sin\left[\frac{Vt}{r}\left(\frac{\pi r}{l} - 1\right) - \frac{V\tau}{r}\left(\frac{\pi r}{l} - 1\right)\right]$$

or finally

$$\sin Kt + \sin K't,$$

$$\sin (Kt - \alpha) + \sin (K't - \alpha'),$$

$$\sin (Kt - 2\alpha) + \sin (K't - 2\alpha'),$$

$$\Sigma \sin (Kt - \alpha) + \Sigma \sin (K't - \alpha'),$$

will be zero provided that

$$\alpha = \pm \alpha' = \frac{2\pi}{3},$$

$$\alpha = \frac{V\tau}{r}\left(\frac{\pi r}{l} + 1\right) \alpha' = \frac{V\tau}{r}\left(\frac{\pi r}{l} - 1\right)$$

$\alpha = \pm \alpha'$ is only possible if $\frac{\pi r}{l}$ is *small*.

Bridge of average or long span.

$$\alpha = \frac{2\pi}{3} \text{ corresponds to } \frac{V\tau}{r} = \frac{2\pi}{3},$$

$$\frac{V}{r} \times \frac{\lambda}{V} = \frac{2\pi}{3}, \lambda = \frac{2\pi r}{3}.$$

A condition which was *mentioned above*.

*By virtue of these two conditions*, $\lambda = \frac{2\pi r}{3}$ and $\frac{\pi r}{l}$ is small, the second member of the Lagrange equation disappears and the equation simplifies itself to $q'' + \alpha^2 q = 0$ which corresponds to the *free vibration of the girder*.

* * *

Considering only a single axle travelling at the critical speed, $y$ will take the following form

$$y = \frac{\beta}{4\pi r N r} \sin \frac{\pi x}{l} \frac{X}{r} \cos 2\pi \frac{X}{2\pi r},$$

X being the abscissa with reference to the origin :

$$\beta = \frac{F}{lm}; N = \frac{1}{T} = \frac{\alpha}{2\pi}; \frac{1}{\alpha} = \frac{l^2}{\pi^2} \sqrt{\frac{p}{\epsilon g}}$$

$$y = \frac{Fl^3}{\varepsilon\pi^4} \times \sin \frac{\pi x}{l} \times \frac{X}{r} \cos 2\pi \frac{X}{2\pi r}$$

$F = \frac{P}{g}\frac{V^2}{r}$ centrifugal force on the balance weight P at the speed V.

The corresponding bending moment is

$$M = \frac{F}{\pi r} \times \sin \frac{\pi x}{l} \frac{X}{r} \cos 2\pi \frac{X}{2\pi r}.$$

We shall see from the following numerical examples that *practically* the critical speed for the motion of free balance weights is reached for bridges of average and long span. On the other hand the critical speed corresponding to the speed effect is *never reached*, being much greater than the first mentioned speed. It would not be possible, therefore, to add the two effects, and we shall see that, in practice, the effect due to balance weights, although not very great, is the one to be considered.

## § 3. — Numerical examples.

In calculating the dynamic stresses we shall suppose that the locomotives are on the bridge in the position where they exert the maximum static effects, in the shape of the maximum bending moments (calculated in the middle of the girder).

We shall suppose, moreover, the free counterbalance weights to be parallel and equal; there being no available data as to their exact numerical values, we shall suppose that, at the maximum speed of translation, they are able to cause a variation of ± 15 % of the axle load.

The calculations and plotted curves are made for two types of locomotive, the *Pacific* with three coupled axles and the *Atlantic* with two coupled axles. The circumference of the wheel is assumed to be equal in the two cases, namely 6.20 m (20 ft. 4 in.). In what follows we shall denote by *speed effect* the effect produced by the load assumed to be constant as the *speed V*. Likewise we shall call the *counterbalance effect*, the effect produced

by the free balance weights with horizontal balancing.

The plotted curves used for determining the speed and counterbalance effects for bridges floors of 60 and 35 m. (205 and 115 feet) span are also given.

As regards the graphical determination of the speed effect, the procedure employed has already been explained and justified. As regards the counterbalance effect the graphical method consists in plotting successively along the length of the girder a number of cosinusoidals of constant length equal to the wheel circumference, the ordinates of this curve at the right hand side of each axle representing, except for the multiplication factor, the relative influence of each of the axles. This graphical method assumes of course that the simplified equation of synchronism is applicable, that is to say, that the speed of translation is actually the critical speed of synchronism.

### I. Case of a single track 60-m. (205 feet) railway bridge.

The period of free vibration T is evaluated at $\frac{1}{3.5}$ sec. i. e. a frequency of *3.5 vibrations per second.*

*Critical speed for the action of the free counterbalance weights* :

$$T_2 = T, \frac{\pi d}{V} = T, V = \frac{\pi d}{T} = 6.20 \text{ m.} \times 3.5 \times \times 3.6 = 78 \text{ km. per hour.}$$

*Critical speed for the speed effect* (constant axle load) :

$$T_1 = T, \qquad \frac{2l}{V} = T, \qquad \frac{2l}{V} = \frac{1}{3.5}.$$

$V = 3.5 \times 120 \times 3.6$ (in km. per hour) $> 1\,200$ km. per hour, *impossible.*

*Speed effect :*

Considering the critical speed for the free balance weights for 80 km. per hour,

$$T_1 = \frac{2l}{V} = \frac{2 \times 60}{80} \times 3.6 = 5.4 \text{ sec.}$$

$$\frac{T}{T_1} = \frac{1}{3.5 \times 5.4} = 0.053 \text{ negligible.}$$

Measurement of the ordinates on the graph and multiplication by $\frac{T}{T_1}$ shows that the effect is practically zero.

*Effect of the free counterbalance weights* :

We assume that F is the same for each of the coupled axles, the balance weights having the same orientation, F being 15 %, at the most, of the static load.

For an axle load of 22 t.,

$$F = 3.3 \text{ t.}$$

For an axle load of 25 t.,

$$F = 3.75 \text{ t.}$$

Calculation on the elements of the curve ultimately shows that for the *Pacific* locomotive (type 10 E. B.) the variation of the bending moment at the *middle* of the bridge for the most unfavourable situation of the train would be

$$1.5 \times \frac{Fl}{\pi^2}$$

$$\frac{Fl}{\pi^2} = \frac{3.3 \text{ t.} \times 60}{\pi^2} = 20 \text{ tms.}$$

Maximum effect = 20 tms × 1.5 = *30 tms.*

*Considering* the 3 885 tms of the maximum static moment $M^T$, this effect *does not even represent 1 %.*

With an engine of the *Atlantic* type, having two 25-t. coupled axles, balance-weight effect in the most unfavourable

static position would be represented for the bending moment by the expression

$$K \times \frac{Fl}{\pi^2}.$$

$$K = 10.3.$$

$$\frac{Fl}{\pi^2} = \frac{3.75\text{t.} \times 60}{\pi^2} = 22.8 \text{ tms.}$$

*Additionat moment* : 22.8 tms × 10.3 = 235 tms.

Maximum static moment : 3 450 tms.

Proportion of the dynamic effect : = 6.8 %.

*At the speed of 120 km.* (74.6 miles) per hour, the cumulative axle distance λ for the speed effect would be

$$\frac{\lambda}{V} = T = \frac{1}{3.5},$$

$$\lambda = \frac{120}{3.5 \times 3.6} = 9.50\ m.\ (31 \text{ ft. } 2 \text{ in.})$$

II. **Bridge of 35 m. (115 feet) span.**

It may be taken that this bridge makes 5 vibrations per second, i. e. $T = \frac{1''}{5}$, the period of *free* vibration.

*Critical speed for the free balance weights* :

$$V = \frac{\pi d}{T} = 6.2 \times 5 \times 3.60 \text{ in km. per hour}$$

= 112 km./h., practically corresponding with the actual maximum speed of *120 km.* (74.6 miles) per hour.

*Critical speed for the speed effect :*

$$T = T_1, T_1 = \frac{2l}{V} = T, V = 5 \times 70 = 350 \text{ m./sec.}$$

i. e. 3.6 × 350 = 1 250 km./h. an unattainable speed, impossible in practice.

*Assuming a maximum speed of 110 km.* (*68 35 miles*) *per hour* :

$$T_1 = \frac{70}{110} \times 3.6 = 2.28 \text{ sec}$$

$$\frac{T}{T_1} = \frac{1}{5 \times 2.28} \simeq \frac{1}{11.5}$$

$$\frac{\gamma_2}{\alpha_2} < \frac{1}{100}.$$

The measurement of the ordinates on the graph shows that the speed effect is *practically zero* for the two *Pacific* and *Atlantic* locomotives.

The cumulative axle distance λ for the speed :

$$\frac{\lambda}{V} = T ; \lambda = \frac{1}{5} \times \frac{110}{3.6} = 6.10 \text{ m}$$

*Counterbalance-weight effect* :

*Pacific* type, group of coupled axles of 22 t. per axle.

$$\frac{Fl}{\pi^2} = \frac{3.3 \times 35}{\pi^2} = 11.70 \text{ tms.}$$

Balance weight effect $K \times \frac{Fl}{\pi^2}$; K measured on the graph = 1.125.

$$1.125 \times 11.7 \text{ tms} \simeq 13.2 \text{ tms.}$$

*Maximum static moment* is about 1 200 tms.

Therefore, in this instance, the balance-weight effect is *a little more than 1 %*.

*Atlantic* type, with two 25-t. coupled axles

$$\frac{Fl}{\pi^2} = \frac{3.75 \times 35}{\pi^2} = 13.3 \text{ tms.}$$

Factor K *due* to the balance weights, measured on the graph, K = 8.3.

*Additional moment* 13.3 tms × 8.3 = *110 tms.*

An increment of between 9 and 10 % of the maximum bending moment.

*a)* **Sous circulation d'une locomotive type « Pacific » (type 10 E. B.)**

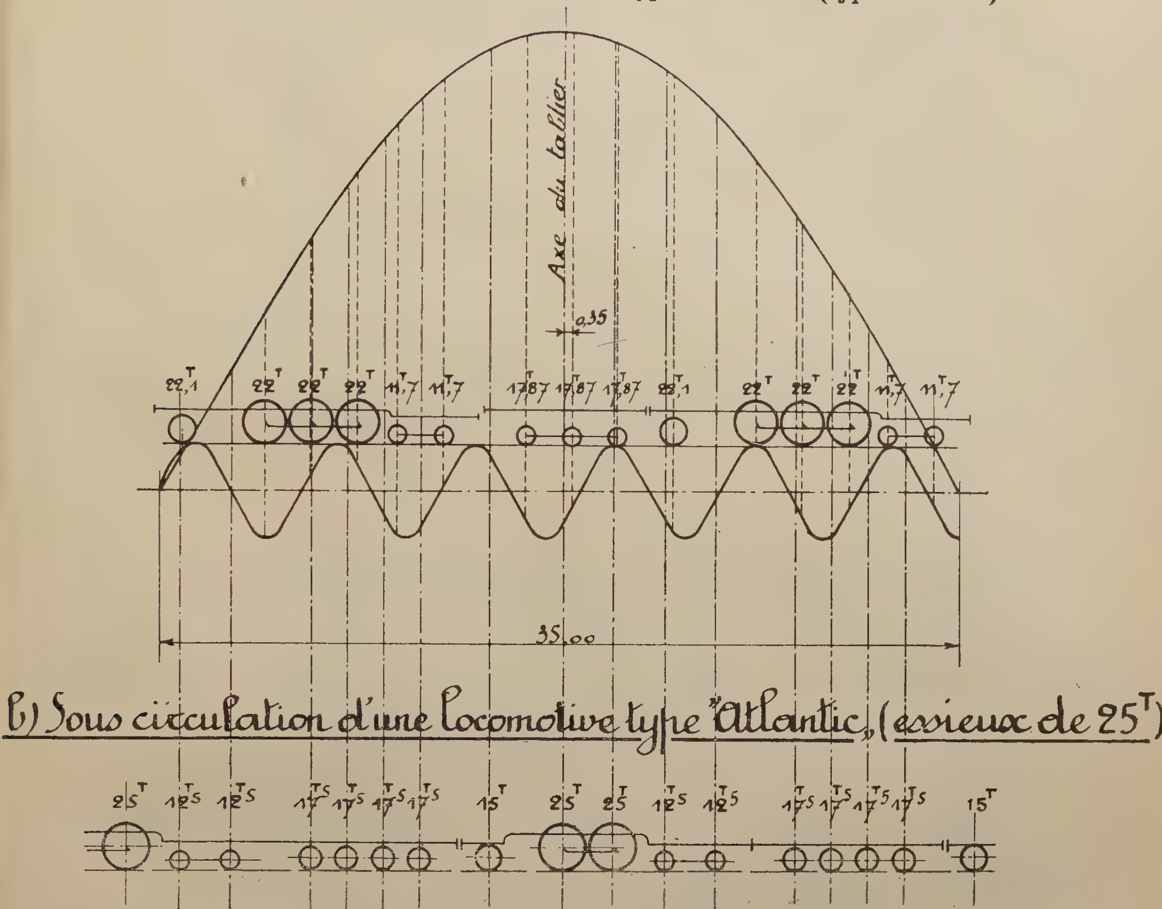



Fig. 1. — Effect of speed on a 35-m. (115 feet) span bridge.

*Explanation of French terms* : *a)* Sous circulation... = Bridge run over by type 10 *Pacific* locomotive of the Belgian State. — *b)* Sous circulation... = Bridge run over by *Atlantic* type locomotive (25-t. axle load).

### III. — Comparison between the results of the French and German impact formulæ.

The French formula is :

$$I = 1 + \frac{0.4}{1 + 0.2L} + \frac{0.6}{1 + 4\frac{P}{S}},$$

L being the span,
P the permanent load,
S the additional load.

We shall use this formula by adopting bending moments for P, the uniform load per metre and for S, the equivalent additional load.

The German formula for comparison is :

$$\varphi = 1.19 + \frac{21}{L + 46},$$

the track being fixed directly on longitudinal sleepers of the main girders.

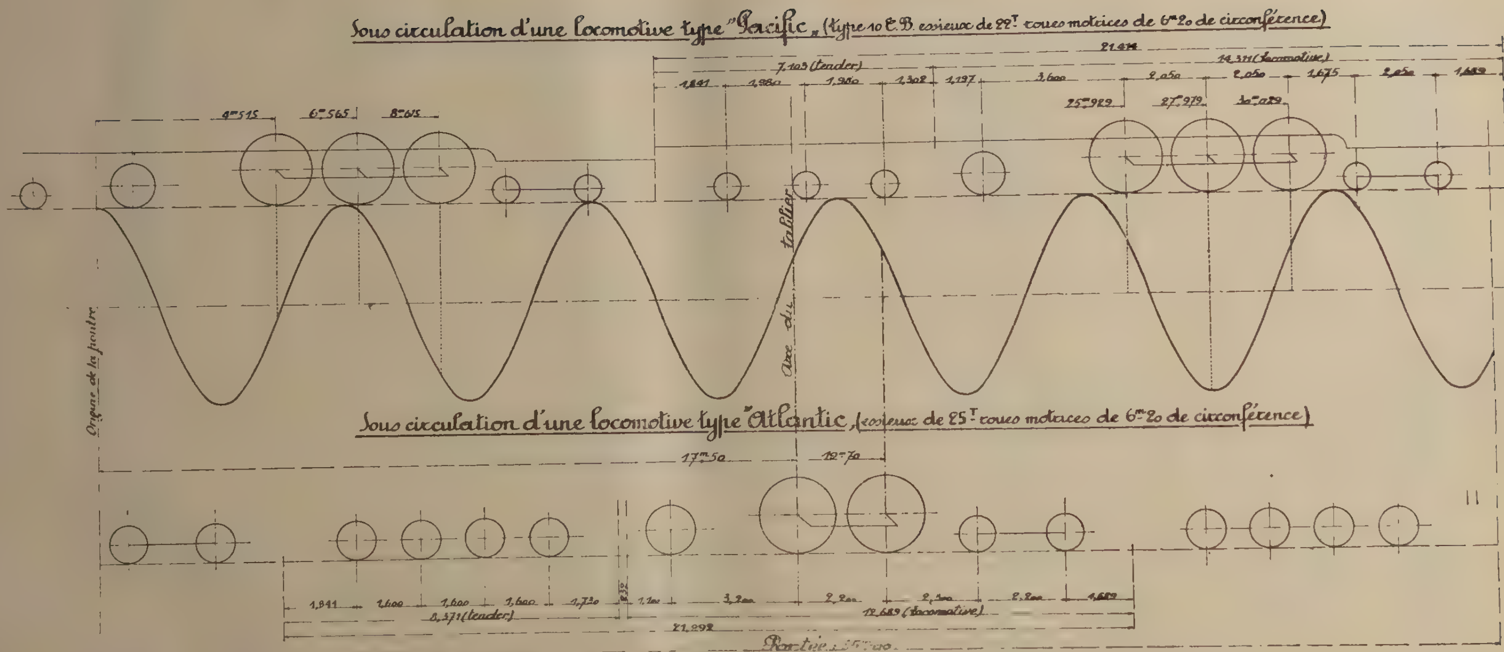



Fig. 2. — Influence of free counterbalance weights on a 35-m. (115 feet) span bridge.

*Explanation of French terms* : Sous circulation d'une locomotive type *Pacific* etc = Bridge run over by *Pacific* locomotive (type 10 of the Belgian State, 22 t. axle loads, circumference of driving wheels 19 ft. 4 in.). — Sous circulation d'une locomotive type *Atlantic* etc... = Bridge run over by *Atlantic* locomotive (25-t. axle loads, circumference of driving wheels 19 ft. 4 in.). — Portée 35 m. 00 — 115-foot span.

*a*) **Sous circulation d'une locomotive type « Pacific » (type 10 E. B.)**

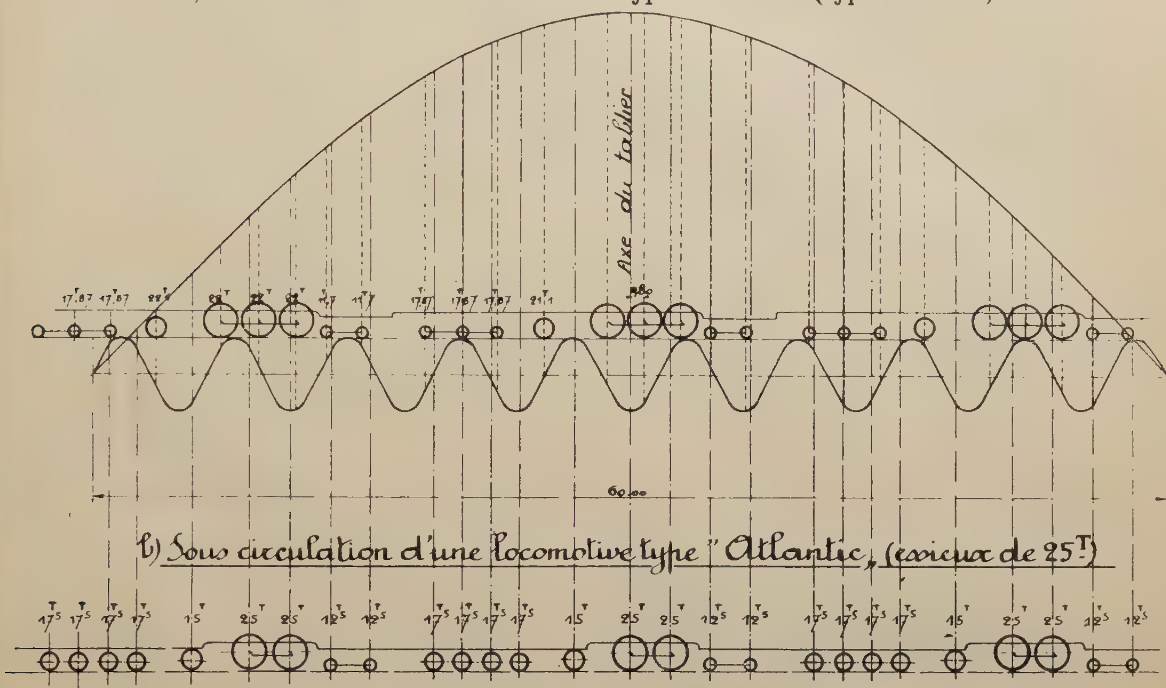



Fig. 3. — Effect of speed on a 60-m. (205 feet) span bridge.

*Bridge floor of 60-m. (205 feet) span.*

Permanent load assumed for a single-track bridge : 4.15 t.

Additional load : 11.8 t.

$$\frac{P}{S} = \frac{4.15}{11.8} = 0.35,$$

$$\alpha = \frac{0.4}{1 + 0.2\,L} = \frac{0.4}{1 + 0.2 \times 60} = 0.03,$$

$$\beta = \frac{0.6}{1 + 4\dfrac{P}{S}} = \frac{0.6}{1 + 4 \times 0.35} = 0.25,$$

$$I = 1 + 0.03 + 0.25 = 1.28.$$

The corresponding German coefficient is $\varphi = 1.39$.

$$I = 1.26, \qquad \varphi = 1.39.$$

Taking into account the maximum working stresses allowed by the two Regulations :

1 300 kgr. French Regulation = R.

1 400 kgr. German Regulation = R.

the section of an element submitted to simple force (e. g. the members of a trellis-work bridge) will be proportional to the quotient

$$\frac{P + SI}{R} = \Omega.$$

In the case considered, the values of $\Omega$ are :

$$\left.\begin{array}{l} \textit{French}\text{ Regulation } \dfrac{19.25}{1.3} = 14.8 \\[2ex] \textit{German}\text{ Regulation } \dfrac{20.55}{1.4} = 14.7 \end{array}\right\} \text{ Identical results.}$$

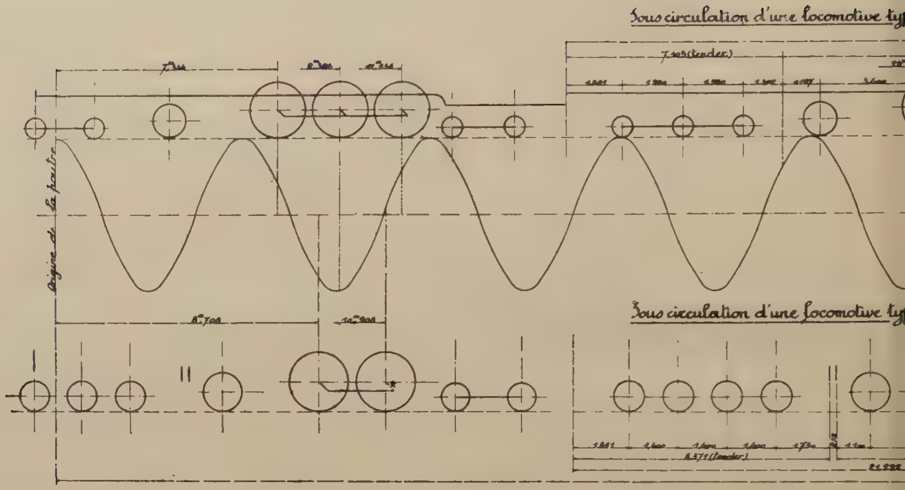



Fig. 4. — Effect of free counterbala

*Floor of 35-m. (115 feet) span.*

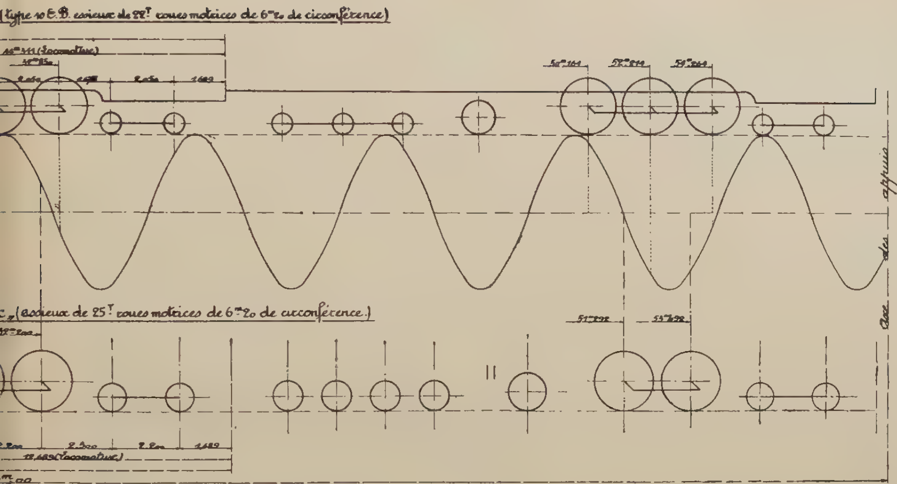
$$P = 3.16 \text{ t.}, \qquad S = 13.3 \text{ t.}$$
$$\alpha = 0.05, \qquad \beta = 0.31.$$
$$I = 1 + \alpha + \beta = \mathbf{1.36},$$
$$\varphi = \mathbf{1.43}.$$

$$\left.\begin{array}{l} \Omega \text{ French} = \dfrac{21.26}{1.3} = \mathbf{16.3} \\[2ex] \Omega \text{ German} = \dfrac{22.16}{1.4} = \mathbf{15.9} \end{array}\right\} \text{Practically equal.}$$

*Floor of 12 m. (39 ft. 4 1/2 in.).*

$$P = 2.05 \text{ t.}, \qquad \frac{P}{S} = 0.13,$$
$$S = 15.8 \text{ t.},$$
$$\alpha = 0.12, \qquad \beta = 0.395,$$
$$I = 1 + \alpha + \beta = 1.515,$$
$$\varphi = 1.55.$$

$$\left.\begin{array}{l} \Omega \text{ French} = \dfrac{26.05}{1.3} = \mathbf{20} \\[2ex] \Omega \text{ German} = \dfrac{26.55}{1.4} = \mathbf{19} \end{array}\right\} \text{Practically equal.}$$



...ts on a 60-m. (205 feet) span bridge.

## IV. — Comparison with the recent English rules.

The 1928 English « Report of the Bridge Stress Committee » contains tables of equivalent maximum loads for calculating steel railway bridges, these loads having been increased to take into consideration the dynamic effects.

These effects consist in :

1. the balance-weight or « hammer-blow » effect;
2. the effect of shock at a rail joint.

The balance-weight effect is evaluated *a priori* for each typical train for calculation. If we merely consider the heaviest train (20 units loading) it consists essentially of 4 coupled driving axles according to the diagram shown below; the gross load of the total balance weight is estimated *a priori* at *0.2* $n^2$ tons ($n$ being the number of revolutions per second) the maximum load in question being concentrated on the two middle axles.

Each axle is normally loaded with 20 tons (20 units loading).

The table of impact loads is summarised below :

**Train A** (Hammerblow 0,2 $n^2$ tonnes)

| Fréquence | ( ) 5' | ( ) 5' | ( ) 5' | ( ) | Total |
|---|---|---|---|---|---|
| 6 révolutions par seconde | 0 | 3t6 | 3t6 | 0 | 7,2 |
| 4,5 | 0 | 2t02 | 2t02 | 0 | 4,04 |
| 3 | 0 | 0t9 | 0t9 | 0 | 1,8 |

*Explanation of French terms* : Fréquence = Frequency. — 6 révolutions par seconde = 6 revolutions per second.

These hammerblow loads are not excessive. The speeds of 3, 4.5, 5 and 6 revolutions per second would correspond taking a wheel circumference of 6.20 m. (20 ft. 4 in.) as a basis, to translational speeds of 67 km., 100 km., 112 and 134 km. (41.6, 62, 69.6 and 93.2 miles) per hour.

The *joint effect* is likened to the action of an isolated load, equal for all spans to $\frac{n^2}{6}$, and therefore only depending upon the square of the angular velocity of the wheels.

The total equivalent excess load is equal to $\frac{n^2}{3}$.

These assumptions are rational.

Comparing the total values for the loads given in the table annexed to the Report and the previous values for the static loads, it is easy to deduce the total proportional increments and to compare them with the similar values given by the French and German formulæ.

The English Report also points out a *third cause* of increase in the impact loads. This is what is termed « lurching », or the rolling of the locomotive. The result of this effect is to load and unload periodically the springs on each side of the locomotive.

The English Report advises that a value of 25 % of the static load should be attributed to this effect; fundamentally it would be a question, therefore, of an unequal distribution over the cross-section. The tables given below show the total equivalent in tons.

$\Delta$ is the total variation (balance-weight + joint).

$\Delta_1$ is the total balance weight variation.

The values of $\Delta$ and $\Delta_1$ are given as percentages of the static load.

TABLE 1. — *Speed : 3 revolutions per second, i. e. 67 km. (41.6 miles) per hour.*

| Span, feet. | Static, tons. | Dyn., tons. | Δ Total, tons. | Δ % | Shock. | $\Delta_1$ | $\Delta_1$ % | Lurching, % |
|---|---|---|---|---|---|---|---|---|
| 13 | 59 | 64 | 5 | 8.5 | 3 | 2 | 3 | 25 |
| 40 | 130 | 145 | 15 | 11.5 | 3 | 12 | 9.25 | 25 |
| 115 | 297 | 360 | 63 | 21.5 | 3 | 60 | 20 | 25 |
| 205 | 484 | 572 | 88 | 18 | 3 | 85 | 17.50 | 25 |

TABLE 2. — *Speed : 4.5 revolutions per second, i. e. 100 km. (62 miles) per hour.*

| Span, feet. | Static, tons. | Dyn., tons | Δ Total, tons. | Δ % | Shock. | $\Delta_1$ | $\Delta_1$ % | Lurching, % |
|---|---|---|---|---|---|---|---|---|
| 13 | 59 | 71 | 12 | 20 | 6.75 | 5.25 | 8.9 | 25 |
| 40 | 130 | 163 | 33 | 21.5 | 6.75 | 26.25 | 20 | 25 |
| 115 | 297 | 360 | 63 | 21.5 | 6.75 | 56.25 | 18.9 | 25 |
| 205 | 484 | 572 | 88 | 18 | 6.75 | 81.25 | 16.9 | 25 |

TABLE 3. — *Speed : 6 revolutions per second, i. e. 134 km. (83.2 miles) per hour.*

| Span, feet. | Static, tons. | Dyn., tons. | Δ tons. | Δ % | Shock. | $\Delta_1$ | $\Delta_1$ % | Lurching, % | German Formula, % |
|---|---|---|---|---|---|---|---|---|---|
| 13 | 59 | 82 | 23 | 39 | 12 | 11 | 18.8 | 25 | 61 |
| 40 | 130 | 184 | 54 | 41 5 | 12 | 42 | 32 | 25 | 55 |
| 115 | 297 | 382.5 | 85 | 28.5 | 12 | 73 | 24.5 | 25 | 49 |
| 205 | 484 | 572 | 88 | 18 | 12 | 76 | 15.8 | 25 | 39 |

The percentage variations of impact as deduced from the English tables are difficult to compare with the corresponding figures of the German and French formulæ, the basis on which the estimations are made being probably rather different. However, taken into account the increase due to lurching, and considering moreover that this distribution mainly affects the longitudinal sleeper with dissymetrical distribution over the main girders, we come to this conclusion, that the total percentages applicable to the main girders attain comparable values, whatever formula is used.

It should again be pointed out that the percentages applicable to the *counterbalance weight effect alone* deduced from the English tables and from the direct theoretical calculations previously given, are fairly different.

*Speed of 100 km. (62 miles) per hour.*

| Spans, Metres. | Feet. | English result, % | Theoretical formula, % |
|---|---|---|---|
| 35 | 115 | 18.9 | 10 |
| 60 | 205 | 16.9 | 6.8 |

If all the combined effects are considered, the balance weight effect representing but a small fraction of the whole, we estimate that there would be no disadvantage in determining it by the simple graphical procedure applied in the previous considerations, except that it would be necessary to multiply it by a co-efficient to be selected empirically.

## V. — General conclusions.

The numerical results, deduced from the calculations applied to the two bridges of 60 m. (205 feet) and 35 m. (115 feet) span show clearly, in fact, that :

1. The dynamic increments due to the speed effect are quite negligible.

2. The increments due to the balance weight effect, although not negligible, are not very important.

3. The critical speeds for the two effects in question being totally different, the maximum effects are usually never produced at the same time.

4. It is probable that these conclusions are applicable to all spans.

5. In order to determine the maximum effect of the free counterbalance weights, a simple method appears to be the graphical method of applying the synchronisation equation for bridges floors, the spans of which are compatible with the critical speed. The annexed graphs show that this application is very simple.

6. Theoretical and practical deductions show that, for a locomotive of the « Pacific » type with 3 coupled axles at $\frac{2\pi r}{3}$ apart, the counterbalance weight effect is practically zero, whatever the span. On the other hand, it is fairly appreciable for locomotives of the « Atlantic » type, and the same would apply for locomotives with 4 or 5 coupled axles balanced under the same conditions. From the point of view of the *counterbalance weight effects* it appears to be well proved that the « Pacific » types, with a group of 3 coupled axles such that the balance weights for horizontal balancing are parallel and equal, are the best. In this respect, it would be *recommendable* in future for locomotives having 4 and 5 coupled axles to be built on lines following these conclusions, that is to say, the balance weights for horizontal balancing being restricted to a group of three neighbouring axles.

7. The other main causes being the shocks, it is naturally evident :

*a*) That the rails on bridge floors should be long and without joints or with welded joints; if the joints are not welded, every effort should be made to place them at the ends of the bridge.

*b*) That some of the shocks are equally due to the variable elasticities of the bed when the moving loads run on to the bridge floor. These loads pass from the ordinary track with fairly flexible ballast on to the masonry of the bridge abutments and then on to the bridge itself. The differences in flexibility of the locomotive supports give rise to parasitic movements of the body of the engine on its springs, which make themselves felt by corresponding load variations. It is advisable, therefore, on the one hand, to strengthen the track at the approaches to the bridge as much as possible by increasing the number of sleepers and the depth of ballast, while suppressing entirely a bad practice in bridge work, which consists in laying an end sleeper on masonry. It has, moreover, been repeatedly found that the masonry below these supports becomes broken down.

[ 624 .2 ]

# REPORT No. 4

**(all countries except America, the British Empire, China, Japan, Belgium, France and their Colonies)**

## ON THE QUESTION OF THE INVESTIGATION INTO THE STATIC AND DYNAMIC STRESSES IN RAILWAY BRIDGES (SUBJECT III FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION (1),

By ALBERTO FAVA,

ENGINEER, CHIEF INSPECTOR IN THE PERMANENT WAY DEPARTMENT OF THE ITALIAN STATE RAILWAYS.

Figs. 1 to 5, pp. 3135 and 3136.

1. — *Foreword.* The classical methods of structural engineering provide reliable principles for calculating, with every desirable precision and accuracy, from the point of view of statics, the tensions per unit cross-section in any bridge member. It is often thought that such precision may also be attained in practice and consequently it is no uncommon thing to see stresses calculated to the hundredth part of a kilogramme per square millimetre.

To a considerable extent, however, such precision is misleading. Anyone who has, to any extent, been engaged in the experimental study of bridges knows that, although as regards the elastic flexures — a sum total phenomenon which is the resultant of all the local deformations, and consequentliy is merely a function of the mean strains or mean stresses — a remarkable agreement is to be found between the recorded results and the calculated results, this agreement is far from showing itself as regards the tensions per unit cross-section. It may even happen that changes in sign are observed, that is to say, compressional forces are found when, according to the calculation, tensile forces ought to be found, and vice versa.

This is due to the fact that, in the ordinary calculations, owing to the necessity for simplification, important modifications are introduced in the system under investigation, the various elements composing it being isolated, and a considerable portion of the stresses, originating from the connection between these elements are ignored. In the present state of structural engineering, it ought to be possible theoretically to allow for the effect of these connections, that is to say the stresses known as secondary stresses arising from the fact that all the bars are rigidly connected, but this would give rise to inextricable calculations that do not allow of any practical application.

Another considerable simplification is always made tacitly, namely, the loads stressing the bridges are considered as occupying the most unfavourable position with respect to the different parts of the bridge, but in a state of rest, while actually it is a question of trains

(1) Translated from the Italian.

running over the bridge at speed. In other words statical methods are applied to a problem which is essentially one of dynamics. In this connection also, it must be noted that the mistake made in this case does not merely consist in the difficulty of applying theoretical principles to practical cases — it is the theory itself which is at fault, since in a large measure the dynamics of bridges are yet to be settled.

In order, therefore, exactly to determine the stresses set up in bridges, and particularly steel bridges, and in order for progress to be made in the design of these structures, there are two kinds of investigation to be made: 1. practical determination from the point of view of statics of the secondary stresses due to the rigid connection between the different parts; 2. determination of the dynamical effects and stresses.

These determinations should not be based on theoretical analysis and laboratory research alone, but ought to be the fruit of observation and experiments made upon existing structures stressed under the actual conditions of railway operation. Any work done in this direction, while evidently possessing a scientific character, cannot therefore be done by individuals, but should, to a large extent at least, be carried out by the important railway administrations, who alone possess the means for doing so.

It is therefore very opportune that the Permanent Committee of the International Railway Congress Association has decided to include the examination of the question: „Study of the static and dynamic stresses in railway bridges" in the programme of the 1930 Session of the Congress.

The questionnaire compiled by the present Reporter was sent to 90 Railway Administrations. Very few, however, supplied any information. One, however, the Administration of the Swiss Federal Railways, which for some years now has been making a very complete and valuable series of investigations on the subject, sent full information.

It appears from the replies that many administrations are taking a keen interest in the problem, that several are making investigations, but that so far very few facts have been established with the precision which is necessary if they are to be used in the ordinary calculations.

Other bodies are actually engaged in studying the problem, which at the present moment is engaging the close interest of the technical world; but here again, as far as is known, very little progress has been made in the solution.

The present Report cannot, therefore, give many definitely determined results. It will generally have to be confined to reporting the position and the research programmes formulated.

### Static stresses.

2. — *Main and secondary stresses.* — It may be useful in the first place to define the meaning with which the expressions « main stresses » and « secondary stresses » are used in this Report.

A steel bridge is made up of a system composed of bars rigidly connected together at their ends. The calculation of such a system would present practically insurmountable difficulties; for this reason it is simplified by assuming that a considerable number of the connections at the ends of the bars are absent. The rigid connections of the lattice bars to the booms, and the junctions of the different bars forming the booms, the

rigid connections of the floor beams to the main girders, and of the track stringers to the floor beams, etc. are thus assumed to be non-existent. The forces obtained in the systems, after making these simplifications, are called *main stresses;* those due to the connections and which in the ordinary calculation are ignored are called *secondary stresses.* The simplified theoretical system may still be statically indeterminate or hyperstatic, because there may still be a considerable number of bars and reactions which cannot possibly be assumed to be removed without the actual system losing its character. The main stresses, therefore, may be either statically indeterminate or hyperstatic. The secondary stresses are always statically indeterminate, and a distinction might be drawn between the normal secondary stresses, which still exist in the most perfect structures, and the abnormal secondary stresses set up by defective structural layouts.

There is nothing to be said regarding the statically determinate main stresses; the statically indeterminate main stresses will therefore be considered, and afterwards the normal and abnormal secondary stresses.

3. — *Main stresses in statically indeterminate systems; multiple triangular systems.* — Where the static indeterminates are few in number and are well defined, the methods of structural engineering always afford a means of calculating the main stresses with sufficient approximation.

An important case in which theoretical analysis allows a certain ambiguity to remain is that of the multiple lattice girders; in fact even when such girders are as a whole statically determinate, like simply supported girders, the plurality of the triangular systems gives rise to numbers of hyperstatic indeterminates which complicate the problem considerably. Theoretical considerations by themselves leave doubt on the question as to whether the shearing stress is distributed equally among the bars meeting in a given section, or whether it is distributed in proportion to their cross-section, that is to say, whether it is the total stress or the stress per unit cross-section which is equal for bars cut by a vertical cross-section.

It is here that experimental work helps us out of the difficulty — numbers of tests carried out by different administrations have shown in fact that, when there are upright stiffening bars, the shearing stress is distributed very approximately in proportion to the cross-section of the bars, both in the case of multiple triangular systems, and double triangular systems in the form of St. Andrew's cross (Howe's truss). If the upright stiffeners are absent and if it is a question of a very multiple triangular system, the distribution is still practically the same, provided the difference in the cross-sections is not very great. In the case of double triangular systems in the form of St. Andrew's cross without upright stiffeners, and that of double triangular systems with upright stiffeners and diagonal ties (Wipple type), which in the past have been employed extensively in different countries, it may be assumed that the shearing stress is divided equally in the two systems, if the latter are equally rigid.

With regard to hyperstatic systems in general, in view of the greater uncertainty of the effective value of the unit stresses, an uncertainty which, despite experimental verification, they inevitably present as compared with those which

are statically determinate — and that either owing to inherent difficulties of calculation or because the value of the stresses in the hyperstatic systems themselves is intimately connected with the conditions of support, which, even if originally in a regular position, may in time become subject to abnormal deflections — it might be asked if it would not be wiser to decide with respect to them upon a greater factor of safety for unit stresses than that which is applied for statically determinate systems.

Whatever, however, may be the individual opinions on this subject, it would appear that one ought always to bear in mind the spirit of the aphorism formulated by Waddel in his book, « Bridge Engineering » and which finds considerable application in American practice: « The best method of dealing with hyperstatical stresses is to avoid them ».

4. — *Secondary stresses in lattice girders, depending upon the rigidity of the joints.* — In the ordinary calculations it is assumed that the individual bars are connected at the corners by frictionless joints while actually there are at the corners rigid bands preventing the free rotation of the bars at their extremities and the angular variations between one bar and another. Secondary stresses result from this which have given rise to many investigations both theoretical and experimental during the last half century.

German engineers were the first to publish fundamental articles on the theoretical solution of the problem: Manderla (1878), Engesser (1879), Winkler (1881), W. Ritter (1885), Müller-Breslau (1885), Mohr (1892); in France, Mesnager (1889) began the first systematic experimental researches, and then there ensued investigations and experiments without break, among which should be cited, as worthy of special consideration, those carried out by the Swiss Committee of the Union of Bridge Constructors who for five years (1917 to 1922) went thoroughly into the theoretical and experimental examination of the question.

For some time American engineers in their turn have been actively engaged in these investigations; formerly they neglected these secondary stresses because they almost always adopted hinged structures. Today, however, considering that these hinged structures also do not eliminate secondary stresses, and adopting generally, in accordance with European practice, the use of riveted joints, they also are devoting the greatest attention to these secondary stresses.

This long work has not yet, at least not up to the present in Europe, enabled any precise rules to be formulated for the calculations, applied practically or applicable to the integration of the ordinary methods. Nevertheless, it has undoubtedly served to clear up the ideas and to furnish useful indications as to the subject of the types to be selected and the structural standards to be followed in order to keep the secondary stresses within very narrow limits.

Thus, even the Swiss Committee, which has made the fullest investigations in Europe that have recently been published, valuable investigations from many points of view and which cannot be ignored by anybody who intends to continue these researches, was very modest in its conclusions with regard to data which might serve as rules for the calculations.

Of these conclusions, those which af-

ford interest from this point of view are given below:

*a)* In simple and structurally correct lattice girders, the measured secondary stresses agree in a satisfactory manner, often very closely, with those calculated accurately.

*b)* The less simple the lattice system, the more complicated the combination of forces, the less continuous the characteristic deflection curves, the smaller the ratio of the width to the length of the bars, and the less the agreement between the measured stresses and the calculated stresses.

*c)* In lattices of simple type, with bars converging exactly at the corners, having a ratio between the height and width (Schlankheitsverhältniss), in the plane of the girders, of about 60 to 40, and a fairly large rigidity in the plane normal to the girders, with structurally correct, riveted corners, the secondary stresses are kept within tolerable limits, the secondary stresses having the same sign as the main stresses attain maximum values lying between 15 and 20 % of the usual allowable main stresses.

As will be seen, this last conclusion is the only one to give any quantitative indication.

The conclusions arrived at by the American engineers (the Reporter is not acquainted with the most recent) agree with those shown above, while providing more practical indications. Some of them are given here, taken from a report of the American Railway Engineering Association, and from the book by Waddell to which reference has already been made.

*a)* The greater the uniformity of the bars, the less intense the secondary stresses: sudden changes in length, width and moment of inertia favour the production of secondary stresses.

*b)* If lattices comprise auxiliary members for the purpose of forming fixed points in the main elements, important secondary efforts are produced in the vicinity of these points: the best arrangement as regards the secondary stresses is that in which all the elements form part of the main system, so that their stresses vary progressively with the increase in the moving load.

*c)* The smallest secondary stresses are found in equilateral triangle lattices and K-lattices without secondary elements.

*d)* When, in two systems, the general dimensions and the moments of inertia are proportional, the percentage of the secondary stresses varies with the ratio of the width of the bars to their length; and this because in the two systems, if the main stresses are equal the angular deformations, the tensions in the end fibres are proportional to the ratio between the width and the length.

*e)* By starting out from the principle given above, and after performing the exact calculation of several fundamental types of lattice girders, it is possible to deduce, with sufficient exactitude, the value of the secondary stresses by using the ratio of the width to the length of the bars as a basis.

Other conclusions could be quoted, but it will be merely pointed out that the estimation of these secondary stresses has already entered into American practice, at least as regards the important works. And this is done either as regards the calculations in which the secondary stresses are generally estimated, by simplified methods, by successive approximations, or as regards the erection, for which arrangements are adopted that are suitable for restricting the production of these stresses.

It appears that from now on this practice ought to be followed by everybody. Taking advantage of the lengthy investi-

gations which have already been done on this problem, the secondary stresses in several fundamental types, which types for each railway are always few in number, should be determined as accurately as possible both experimentally and practically; then, knowing the secondary efforts in these types, the approximate value of the stresses in different special cases could be deduced by methods of approximation starting out for example with the value for the above-mentioned ratio between the width and the length of the bars.

In order to amplify the statements given above, it has been thought expedient to reproduce several curves (figures 1, 2, 3, 4 and 5), some of which have been taken from a paper by Professor Patton of Moscow, and some have been provided by the Swiss Federal Railways; these curves represent the relationship between the secondary stresses and the above-mentioned characteristic ratio of the width of the bars to their length.

5. — *Secondary stresses due to the moments of partial fixation at the ends of the floor beams and the track stringers.* — The transverse girders of steel bridges are generally rigidly connected at the ends to the main girders, and consequently under load moments are developed about these ends, constituting as regards the floor beams moments of partial fixation, and as regards the main girders, moments of torsion. The same applies to the attachment of the track stringers to the floor beam. These moments give rise to a second category of normal secondary stresses, also very important and which have been extensively investigated.

The theoretical determination of these stresses is likewise very complicated because the moment of partial fixation of each floor beam, depending upon the resistance to torsion offered by the main girders, is a function of the partial fixation to which are subjected all the other floor beams. It has been deemed necessary therefore to make use in this case also of experiments among which those carried out some time ago by the Italian, Swiss, and French railways will be considered as having an outstanding importance.

The main conclusions are the following:

*a*) The degree of fixation of a floor beam (ratio between the effective bending moment and the moment of perfect fixation) varies not only with the type of span, and mainly according as the span is open or closed, but for one and the same span, it varies according to the position occupied by the floor beam, that is to say, according as the beam is situated towards the ends or the middle of the span; and for one and the same floor beam it varies with the intensity and the mode of distribution of the load over the whole bridge. Consequently, the degree of fixation cannot be defined by a single value either for all the floor beams of one span or for a given floor beam.

*b*) The degree of fixation in a girder submitted to the maximum load is a minimum when all the floor beams of a span are loaded equally; it is a maximum when the floor beam is alone loaded. In the first condition of loading, it is smaller for the floor beams situated towards the centre of the span, and larger for those near the supports.

*c*) In the experiments carried out with one locomotive alone, the value of the degree of fixation of the floor beams placed near the centre — the theoretical width being assumed equal to the

Figs. 1 to 4. — Graphs showing the relationship between $\frac{N}{n}$ and $\frac{l}{e}$ or $\frac{l}{b}$ according to the investigations of Professor Patton.

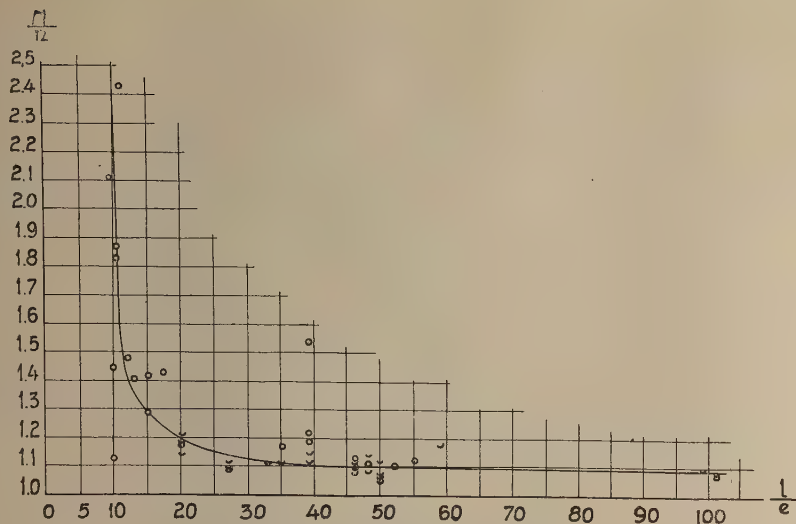


Fig. 1. — Flanges near the supports.

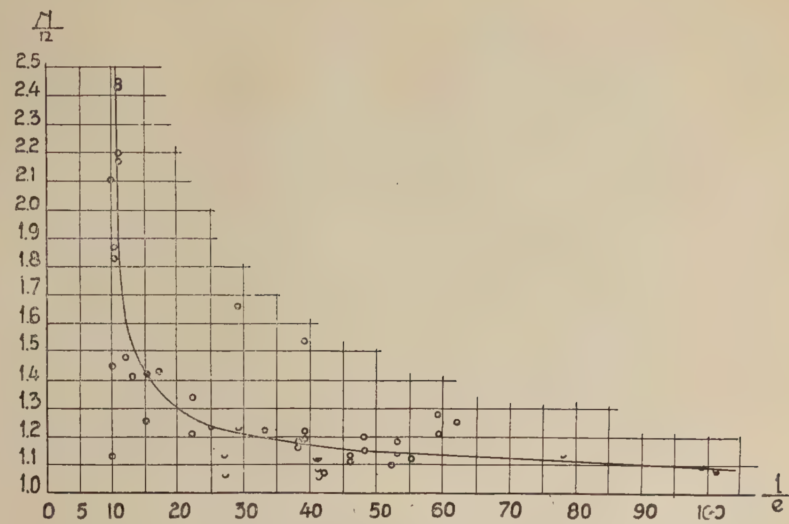


Fig. 2. — Flanges near the middle.

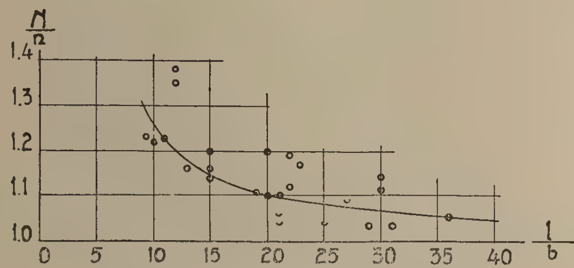


Fig. 3. — Diagonals near the supports.

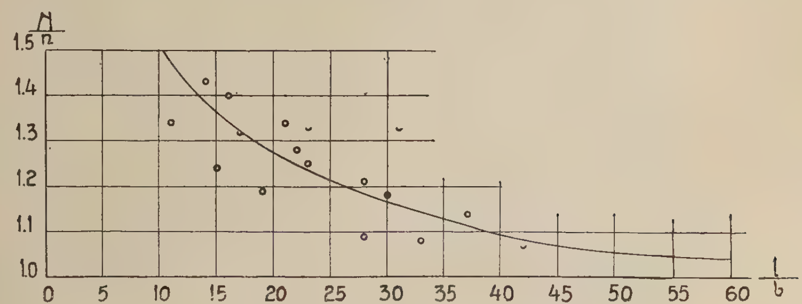


Fig. 4. — Diagonals near the middle.

N = Total stress.
n = Secondary stress.
l = Length.
b = Width.
e = Distance between the extreme fibre and the centre of gravity.

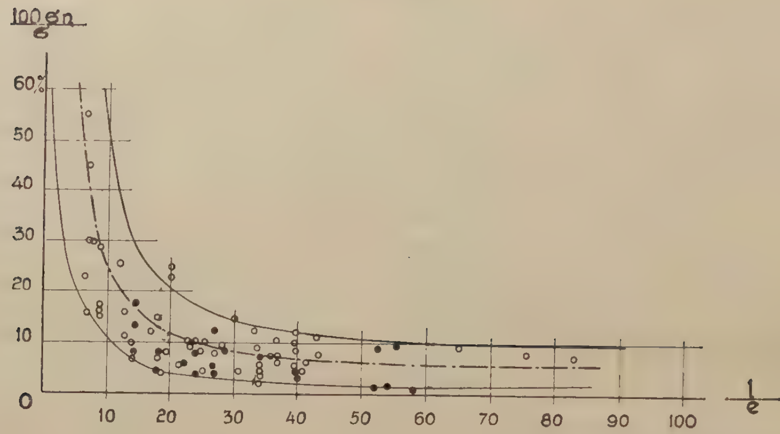



Fig. 5. — Graph showing the relationship between $\frac{\sigma n}{\sigma}$ and $\frac{l}{e}$ according to the experiments of the Swiss Federal Railways.

l = Length.
e = Distance between the extreme fibre and the centre of gravity.
$\sigma$ = Main stress.
$\sigma n$ = Secondary stress.
o = Flanges.
● = Lattice bars.

distance between the axes of the main girders — was never found to be greater than 0.55. It would be greater in the fictitious case of an isolated axle.

d) In the track stringers, the degree of fixation is greater than in the floor beams and in some cases approaches unity.

In this case again, the researches carried out brought out the general extent of the phenomenon, and established general but otherwise intuitive rules. They confirmed the perfect agreement between the experimental results and those provided by theory, when all the variables of the problem are taken into account. For these stresses also, however, it has not been possible to establish definite rules which would enable the degree of fixation to be determined in the different cases with sufficient accuracy without having to enter each time into complicated calculations.

It would appear, therefore, that also as regards these stresses, each administration should proceed to a systematic investigation so as to obtain, for its fundamental types of bridges, numerical coefficients which could afterwards be applied by way of approximation to all the special cases.

While awaiting more definite determinations, however, for the present, the partial fixation should be allowed for in practice by discarding the rule still adhered to by many engineers of calculating the floor beams and the track stringers as if they were merely supported girders, a rule leading to the irrational distribution of the steelwork which is in excess towards the centre and deficient towards the joints. Provisionally, the French Regulations of

1927 might be followed, that is to say, to calculate the maximum bending moment which would be produced in the girder if it was simply supported at the ends and assume that the real moment of fixation varies between a minimum of 20 % and a maximum of 50 % of this maximum moment, the value of 20 % being introduced into the calculation of the medial sections of the girder, and the value of 50 % into the calculation of the sections near the ends, and into the calculation of the joints.

The moment of partial fixation of the floor beams about the upright bars of the main girders may have a prejudicial effect on the latter, not merely owing to the torsional stresses to which they are submitted but also to local actions which are exerted especially in cases where subsidiary uprights are concerned which only extend over a portion of the height of the main girders, and which are intended to transfer the pressure of the floor beams to the points of intersection of the lattice bars. In this case, the uprights may transmit to these points horizontal forces capable of contributing to the lateral deflection of the bars, and it might be advisable to eliminate the moments of fixation by making the ends of the uprights flat in such a manner as to effect a hinged support for the floor beams.

6. — *Secondary stresses depending upon the continuity of the track stringers.* — Generally in steel bridges the stringers carrying the rails are fixed in a continuous manner to the floor beams, which are in most cases fixed to the bottom or top flange of the main girders. Under the action of loads, these bottom and top flanges are liable to extend or contract, respectively, while the axes of the track stringers, under the direct effect of the loads, would have a constant length. The result is that the floor beams are obliged to bend in a horizontal plane; for a span loaded practically uniformly, their deflection is zero at the centre of the span itself, and as it may be assumed that the central floor beam remains straight, this deflection progressively increases on proceeding towards the ends, where the deflection measured opposite the joints of the track stringers, if the length of these latter did not change, would be equal to half the total variation in length of the flange.

Actually, this deflection will be a little less, because the floor beams in offering a resistance to bending, compel the track stringers partly to follow the variation in length of the flanges and cause a part of the axial stresses intended for these flanges to pass into the track stringers.

An action similar to that undergone by the track stringers is exerted on the horizontal wind bracings, which being compelled to follow the deformations of the flanges, also receive a part of their stresses.

The result of this is a fresh category of secondary stresses, the importance of which is far from being negligible, especially as regards the bending stresses in the floor beams. For instance, in a bridge constructed recently near Rome, about 40 m. (131 feet) long and of a perfectly normal type, it was immediately found that the stress per unit cross-sectional area due to the said horizontal flexure is about 5.5 kgr./mm² (3.49 Engl. tons per sq. inch) while the main stress due to the vertical flexure, under the same condition of loading, is about 6.5 kgr./mm² (4.13 Engl. tons per sq. inch).

These secondary efforts are also im-

portant as regards the wind bracings, where they may attain a value equal to more than half the main stresses in the flanges.

They are not so great in the track stringers proper, but they become still more important in these members in the way in which they strain the attachments to the floor beams.

The secondary stresses under consideration thus deserve a close theoretical and practical study if a more rational distribution of the steelwork is desired, by lightening the flanges of the main girders in the plane of the track and which profit by their rigid connection with it, and strengthening on the contrary those elements whose condition is aggravated by the effect of this rigidity.

The precautions to be taken in this case, of a fairly easy and practical application, which are able to reduce this type of stresses, likewise deserve to be investigated. The simplest and surest way consists in breaking the continuity of the track stringers at suitable intervals, for example, every 20 or 30 yards by inserting a sliding attachment. The object may also be achieved by suitable methods of erection by means of which it should not be difficult to introduce beforehand stresses of the opposite sign to those now under consideration.

7. — *Abnormal secondary stresses due to structurally defective arrangements.* — The secondary stresses which have so far been considered are present in all types of bridges, even in those of correct type and of quite recent construction. Others, on the other hand, are due to structurally defective arrangements, usually avoided today in new works, but found in a large number in old constructions. These stresses should be familiar, not only to the engineer responsible for the designs, but even more so to the engineer who has to supervise existing bridges, and who has to judge to what limit such bridges may be loaded.

This category of secondary stresses embraces, for example, those due to the imperfect convergence of the axes of the bars of the joints, and those arising out of the loading of the flanges of lattice girders beyond the joints, stresses which may be examined like those discussed in section 4. There is, however, a class of these secondary stresses which deserves special attention, on account of the high value they attain in many cases and also because they occur in a very large number of bridges, even in those of fairly recent construction; this is the class of stresses produced in main lattice girders owing to the fact that the bars are not arranged symmetrically with respect to the medial plane of the girder.

For the sake of simplicity in the construction of single lattice-work bridges a very frequently adopted method is to attach the bars in compression to one side of the flange webs and the bars in tension to the other side. Under the effect of loads, the flange is subjected to a torsional stress and all the lattice work undergoes an inflection giving rise to supplementary stresses in the bars, not allowed for in the calculations but frequently of considerable magnitude. Numerous cases may in fact be quoted which have been closely examined (Swiss, French, Italian Railways), where these supplementary bending stresses, as measured experimentally, are greater than the normal stresses allowed for in the calculations, to an extent such that the total stresses in the most distant fibres are, on one side of the section, opposite in sign to the normal stresses,

and may attain or even exceed double the value of these normal stresses.

The theoretical determination of these supplementary bending stresses is fairly complex. All the factors capable of opposing the rotation of the flange must be taken into account, that is to say, besides the resistance to torsion of the flanges themselves, the resistance offered by the floor beams and by the stiffening frames.

The experimental determination in this case is, on the contrary, very simple since it is unnecessary to measure these stresses directly, but it is merely sufficient to obtain, by simple methods, the increase in horizontal bending, under load, of the lattice girder and from that to evaluate the bending stresses. It is found that the stresses deduced in this way agree very well with those measured directly.

In order to determine these secondary stresses, fairly simple theoretical formulae have been suggested (for example, in the instructions accompanying the French 1927 Regulations) which contain an empirical coefficient to characterise the conditions of attachment of the bar at its ends. Since this coefficient varies from zero in the case of a hinged joint to infinity in the case of a perfectly rigid attachment, there is the greatest uncertainty in the application of these formulae in different practical cases. It would be advisable, therefore, to measure experimentally for all the typical cases the lateral inflections, and to calculate the resulting stresses, and afterwards to use the values so obtained to determine the empirical coefficient to be applied in similar cases.

On these lines, the Italian Railways have already undertaken some experiments, and it is believed that when there is available a table of coefficients applicable to the different cases, the abovementioned formulae might give useful service, solving in a very simple manner and with great exactitude the problem of the determination of this important class of secondary efforts.

8. — *Determination of the experimental lines of influence of the stresses.* — It follows from the considerations which have so far been discussed, that the main stresses, such as they are obtained in the usual calculations based upon simplifying assumptions, are very far from representing the actual working conditions of the different members of steel bridges. A knowledge of the secondary stresses is therefore essential in order to be able to raise the safety limits at present allowed and to effect a more rational and more economical distribution of the steelwork. These stresses cannot be determined by theoretical means alone, owing to the complicated character of the calculations they involve, and it is therefore necessary to make use of information provided by experiment.

Experiment, however, presents difficulties which are not very light.

For measurements of a static nature, such as those involved here, suitable instruments are already available which satisfy the requirements fairly well, both as regards precision and their practical character. The difficulty does not come from that quarter. It rather lies in the uncertainty to which the interpretation of the results of the measurements give rise, since each recorded value represents the resultant of different forces, each of which, moreover, is due to different loads, that is to say, to as many loads as there are axles on the locomotives or train employed in carrying out the experiment.

As it is a question of systematic researches intended to establish, quantitatively also, the laws according to which certain categories of stresses are produced, it would be necessary to be able to deal separately with these categories and to avoid all interference by isolating the different forces. If, however, this cannot be done, it is necessary at all events to avoid the complications arising out of the plurality of loads. That is why, instead of employing locomotives, it would be better if a rail motor vehicle could be used, specially designed for the experiments, similar to that built by the Swiss Federal Railways. In this vehicle the weight is usually distributed between three axles, but when making the experiments, all the weight may be concentrated on the middle axle, the two outside axles being relieved of load.

In this way, an *isolated* load, of very definite weight can be caused to move on the bridge, and it becomes possible to trace the *experimental lines of influence* of any characteristic: translation, angular variation, local strain. The analysis of the different factors producing the above-mentioned characteristics, carried out on these lines of influence, is incomparably more simple and very much more instructive than that which can be effected on the complex diagrams obtained on the passage of locomotives or trains.

It is the opinion of the Reporter that only by applying the method based on the recording of the experimental lines of influence and on their comparison with the theoretical lines, will it be possible to obtain a sufficiently precise knowledge of the laws governing the production of the stresses in question, a knowledge of a nature enabling it to be applied in practice.

### Dynamic stresses.

9. — *Dynamic coefficients.* — The determination of the effects due to the speed of the loads constitutes an old problem which has arisen ever since the beginnings of the construction of steel bridges for railways, even before the classical statical theories were elaborated. In fact, even as long ago as 1849, i. et 80 years ago, as a result of several accidents which occurred to railway bridges in the country of origin of railways, that is to say in England a Committee was appointed to study this question.

This Committee carried out theoretical and experimental researches. On this occasion Stokes published his classical paper : « Discussion of a differential equation relating to the breaking of railway bridges » which was followed by so many other theoretical papers. The committee also carried out numerous laboratory experiments on isolated bars, the results showing that the effect exerted by the speed may increase by 100 or even 200 % the effect of the static load.

In the records of the old English Committee we find for the first time the notion of *dynamic coefficient*, that is to say, the coefficient by which the static loads must be multiplied in order to allow for all the speed effects.

This coefficient later came to be used generally, and at the present time most railways have their own formula for calculating it.

A few administrations only, such as, for instance, the Italian Railways and the Austrian Railways allow for the dynamic phenomenon indirectly, that is to say, instead of multiplying the static load by a coefficient of increment, the allowable stresses are varied according to the bridge spans.

10. — *Formulæ in force for determining the dynamic coefficient.* — Table I gives the most recent formulæ in force in the more important railway administrations or associations, and Table II shows these formulae in the shape of graphs which have been taken from a recent publication of the Swiss Federal Railways.

All these formulæ express the dynamic coefficient as an inverse function of the length of the girder, and generally as a hyperbolic function.

This is justified by different considerations.

Since it is not a question of the effect of instantaneous shocks, but of loads successively applied in a longer time than the period of oscillation proper of the girder, the dynamic effect of these loads depends upon the rapidity with which they are applied with respect to the period of vibration. It is indeed possible to conceive that the portion of the load exerting the greatest effect is that which comes into effect during the first half-period of oscillation; the part which is applied during the second half-period partly neutralises the effect of the first. Such being the state of affairs, and since at the speed equal to that of the passage of trains, the fraction of the load which may be usefully applied in a half period depends upon the length of the girder, decreasing as this length increases, it is the length upon which the dynamic coefficient may be made to depend.

A start may also be made with the consideration that, as generally in all problems of shock, the dynamic effect will depend upon the ratio of the moving mass to the stationary mass, or, in the case now under consideration, the ratio of the load to the weight of the bridge itself; and since this ratio varies inversely as the length, it is justifiable from this point of view also to express the dynamic coefficient as a inverse function of the length.

Some formulae present peculiarities which should be noted.

The French formula explicitly includes the parameter $\frac{P}{S}$ ratio of the permanent weight P to the load S, expressing for the different elements the dynamic coefficient as an inverse function not only of the length but of this ratio also. This appears to be a very wise precaution on account of both the previously-mentioned physical significance of the ratio itself, and also because by its introduction, it is possible to take into consideration elements and structural arrangements which affect the weight of the bridge itself, and consequently the dynamic effect, as for example, the presence of ballast which causes an increase in weight; the use of very tough steel, which results in lighter structures and consequently structures which are more sensitive to dynamic effects, etc. These elements escape calculation entirely if the parameter length alone is considered.

The Swedish formula expresses the dynamic coefficient as a function of the length and also as directly proportional to the ratio $\frac{V}{100}$, V being the speed in kilometres per hour. In the opinion of the writer, the addition of this factor is also justified, since it appears natural to bring the variable « speed » directly into the expression of an effect which is the direct consequence of this speed. The formula containing this factor also affords the advantage of being adaptable to different working conditions, that is to say, it is able to tell what advantage

TABLE I.

(1) **American Railway Engineering Association** 
**Canadian Society of Civil Engineers** **1925**

$J = \frac{30\,000}{30\,000 + L^2}$ (L in feet) . . . . : (L in metres). $J = \frac{2\,780}{2\,780 + L^2}$

for railway bridges.

(2) **American Society of Civil Engineers . . . 1924**

$J = \frac{2\,000 - L}{1\,600 + 104}$ (L in fee ) . . . . . (L in metres). $J = \frac{610 - L}{488 + 10\,L}$

for highway bridges.

(3) **British Engineering Standard Association. . 1923**

$J = \frac{120}{90 + \frac{n+1}{2} L}$ (L in feet) . . . . (L in metres). $J = \frac{36.5}{90 + \frac{n+1}{2} L}$

$n$ = number of tracks for railway bridges.
= number of bands 3.05 m. (10 feet) wide for highway bridges.

(4) **German Railways . . . . . . . . . . . . 1922**

Track laid on ballast without rail joints . . . . . . . $J = 0.00 + \frac{60}{150 + L}$

Track laid on ballast with rail joints .
Track laid on sleepers without rail joints. . . . . . . . $J = 0.11 + \frac{56}{144 + L}$

Track laid on sleepers with rail joints.
Track laid directly without rail joints. . . . . . . . $J = 0.19 + \frac{21}{46 - L}$

Track laid directly with rails joints. . . . . . . . . . $J = 0.20 + \frac{17}{28 + L}$

for double L or double track bridges

(5) **French Regulations . . . . . . . . . . . 1927**

P = permanent weight ; S = load . . . . . . . . . $J = \frac{0.4}{1 + 0.2\,L} + \frac{0.6}{1 + 4\frac{P}{S}}$

putting P = 2.0 + 0.05 L and S = 11 L. . . . . . . $J = \frac{0.4}{1 + 0.2\,L} + \frac{6.6}{19 + 0.2\,L}$

(6) **Sweden.**

Speed in km./ per hour . . . . . . . . . . . . . $J = \frac{1}{13 + 0.7\,L} \quad \frac{V}{100}$

For V = 100. . . . . . . . . . . . . . . . . $J = \frac{1}{13 + 0.7\,L}$

(7) **Denmark (Lillebelt Bridge) . . . . . . . . 1928**

$Sp$ = action of load . . . .
$Sg$ = action of permanent weight. for each element . . . $J = \frac{1}{1 + \frac{n+1}{220} L} \quad \frac{Sp}{Sp + Sg}$

After elimination of the parameter $\frac{Sp}{Sp+Sg}$ as in the French formula by putting : $\frac{Sp}{Sp+Sg} = \frac{11}{11 + 2 + 0.05\,L}$ and assuming $n = 1$ . . . . . . . . . . . $J = \frac{1\,210}{1\,430 + 18.54 + 0.05\,L^2}$

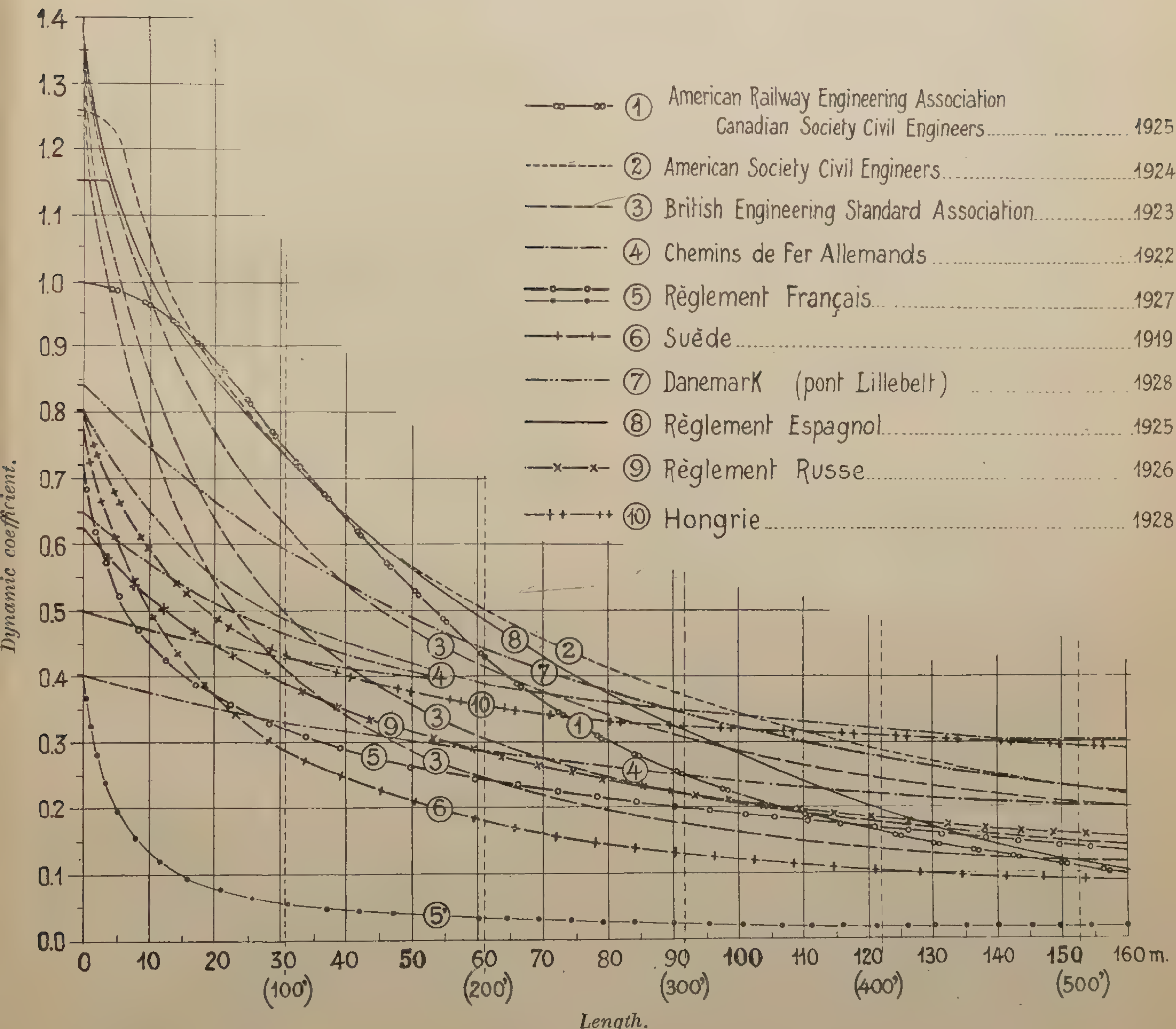
(8) **Spanish Regulations . . . . . . . . . 1925** $J = 1.40 - 0.56\sqrt{500\,L - L^2}$

(9) **Russian Regulations . . . . . . . . . . 1926** $J = \frac{0\ 625}{1 + 0.02\,L}$

(10) **Hungary . . . . . . . . . . . . . . . .** $J = 0.24 + \frac{9}{16\,L}$

TABLE II.

**Dynamic coefficients for railway bridges.**




*Explanation of French terms* : Chemins de fer allemands = German Railways. — Règlement français = French Regulations. — Suède = Sweden. — Danemark (Pont Lillebelt) = Denmark (Lillebelt Bridge). — Règlement espagnol = Spanish Regulations. — Règlement russe = Russian Regulations. — Hongrie = Hungary.

is gained by reducing the speed of trains passing over the bridge which none of the other formulæ do.

The Danish formula (Lillebelt bridge) includes the parameter $\frac{Sp}{Sp + Sg}$ where $Sg$ signifies the stress due to the permanent weight and $Sp$ that due to the load. This parameter which bears some resemblance to the $\frac{P}{S}$ of the French formula, is justified in a similar manner, although perhaps not quite so exactly; it is moreover of less practical use than the French term because it can only be determined after the dimension of the bars to which it refers have been fixed, while the ratio $\frac{P}{S}$ may be fixed approximately even beforehand.

Finally, the German formulae take into account the conditions under which the track is laid, and are evidently useful if, as may be presumed, they are based on tests showing effectively that they reflect these different conditions fairly well.

11. — *Inadequacy of the formulæ at present in force.* — The writer is unaware whether all the different formulae for the dynamic coefficient have been checked by the administrations making use of them either by observations or by tests. He considers that they are rather to a large extent the fruit of theoretical considerations of the type of those previously discussed, considerations well founded in principle but of too general a character.

One fact which appears striking when these formulae come to be examined and which makes itself evident in the graphs, table II, is the considerable difference in the results which they provide. For example, for a span of 20 m. (69½ feet), the dynamic coefficient would be 0.35 according to one of the German formulae and about 0.88 according to the American formulae. For a span of 50 m. (164 feet), the dynamic coefficient varies from 0.21 to 0.56 according to the different formulae; for a span of 100 m. (328 feet), it varies from 0.12 to 0.33.

Although one may desire to assume that the dynamic increment may actually differ in the different countries, according to the type of bridge, the general conditions of upkeep of the permanent way, and the methods followed in balancing the locomotives, and although all that one may desire from these formulae are merely indications of a general order, it still remains that differences of such magnitude between one formula and another cannot be justified and give rise to very legitimate doubts as to their agreement with the actual facts and as to their practical value.

The tests carried out up to quite recently with the view of determining generally the dynamic increment in the different cases have not succeeded in throwing much light on the subject.

It has been proved in a general fashion and confirmed by experiments that the dynamic increment diminishes as the span increases, but quantitatively there have been very considerable discrepancies. The results obtained are characterised by a large dispersion, and are extremely widely scattered, and this mass of results has justly been compared with a nebulus in which no line of condensation can be distinguished.

All this is, moreover, easy to explain. The dynamic increment depends upon a mass of factors : constitution and type of bridge, its state of repair, ultimate state of ballast, state of the track, effect of the rail joints, probable skid flat

on the tyres, abnormal movements of the locomotives, more or less perfect balancing of the driving wheels, etc. The multiplicity of these factors explains very well the wide difference obtained in the experimental results; it also shows how impossible it is to allow for these factors by means of formulae generally containing only one independent variable — the length of the bridge.

Even if one of these formulae, with one parameter or at the most two, were founded on a better basis than the others, and furnished values approximating more closely with the actuality it could only represent average conditions; and as such it would always be insufficient for practical requirements, because it would not enable the different influences to be estimated. Thus, for example, it would not provide a means for knowing whether advantages would be afforded as regards the dynamic increment by eliminating the rail joints through welding, by employing perfectly balanced locomotives, etc.; questions of importance for the designing engineer and still more so for the engineer called upon to decide whether the new locomotives, of ever-increasing weight, can be allowed on old bridges.

In order to make progress in the solution of the problem, a systematic examination of the various chief causes of the dynamic increment should be made by pushing further the mathematical study of those lending themselves to theoretical analysis, by improving the instruments and methods of experimental research, and by contriving to *isolate* and *characterise separately* the different influences.

This work has already been undertaken by several administrations and collectively by the International Railway Union.

It will probably lead to the conception of the estimation of the dynamic increment as a whole by means of a fraction of the static load as given by a single formula being abandoned, and on the contrary will result in different formulae and different criteria being set up to represent the different effects.

12. — *Dynamic effect due to speed alone; centrifugal force; vibrations.* — The main causes of the dynamic effects will now be rapidly reviewed, beginning with the effect of speed alone, that is to say, the effect of a mass moving with a constant speed on a perfectly plane track.

Two cases are distinguished, according as the mass of the load is large or small compared with that of the loaded girder.

*a)* In the first case, when the weight of the girder is small compared with the load, that is to say, for girders of small length, the force of inertia of the load alone may be taken into account, that of the girder being neglected. The dynamic effect is represented in this case by the centrifugal force developed as a result of the curvature assumed by the track under the action of the load, a centrifugal force which is added to the static load and represents the dynamic increment.

The question was originally treated by Willis and Stokes, and more recently by Zimmermann, and the most important practical result for a girder simply supported is summarised, according to the approximate method of Willis, in the following expressions for the total pressure $P_d$ (load plus centrifugal force) transmitted by the load $P$ to the girder:

$$P_d = P\left(1 + \frac{v^2 P l}{3gEI}\right) = P\left(1 + \frac{16 v^2 f_s}{g l^2}\right) =$$

$$= P\left(1 + \frac{8v^2\sigma_s}{3ghE}\right) = P\left(1 + \frac{1}{\alpha}\right)$$

where $v$ = speed of the load,
$g$ = acceleration due to gravity,
$h$ = depth on the girder,

$f_s = \frac{Pl^3}{48EI}$ the static flexure at the centre,

$\sigma_s = \frac{Plh}{8I}$ the maximum static stress at the centre,

$\alpha = \frac{gl^2}{16v^2 f_s} = \frac{3ghE}{8v^2\sigma_s}$, the characteristic coefficient of the dynamic increment.

As a second approximation, according to Zimmermann's results, it may be assumed that

$$P_d = P\left(1 + \frac{1}{\alpha - 3}\right)$$

When, in place of an isolated load, it is a question of a locomotive, the dynamic increment for one axle only may be taken into account; in fact, owing to the action of the springs, the influence on the masses of the other axles is considerably reduced and the load of these axles would be affected by an increment coefficient slightly greater than unity.

The dynamic increment due to the cause under consideration at the moment may, for small girders and for high speeds, become considerable. If in fact we put g = 981 cm. per sec$^2$,

$E = 2 \times 10^6$ kgr. per cm$^2$,

$\sigma_s$ = 800 kgr. per cm.$^2$, the coefficient $\alpha$ assumes the form

$$\alpha = 92 \times 10^4 \frac{h}{v^2}.$$

If now we suppose the girder to be very small, say $h$ = 30 cm., for $v$ = 108 km. (67 miles) per hour = 3 000 cm. per second, the dynamic increment $\frac{1}{\alpha}$, becomes 0.326;

And for $v$ = 72 km. (44.7 miles) per hour = 2 000 cm. per second, the dynamic increment in the same girder is equal to 0.145. If, on the contrary, the girder was 200 cm. deep, then, for the same two speeds of V = 108 km. per hour, and V = 72 km. per hour, the dynamic increment would be respectively 0 049 and 0.022, that is to say negligible.

*b)* When the span of the girder and consequently its own weight increase, the inertia of the girder is no longer negligible compared with that of the load, and the dynamic phenomenon to be taken into consideration in this case is that of vibrations.

According to the researches of Professor Timoshenko, and making the most unfavourable assumption as regards the superposing of the static flexure and that due to the vibrations, the effect of the damping of the vibrations being neglected, the maximum dynamic flexure $f_d$ is given by the formula

$$f_d = f_s\left(\frac{1}{1-\alpha}\right) = f_s\left(1 + \frac{\alpha}{1-\alpha}\right)$$

where $f_s$ is the static flexure and the coefficient $\alpha$, characterising the dynamic increment, is given by

$$\alpha = \frac{T}{2T'}$$

wherein $T = \frac{2l^2}{\pi}\sqrt{\frac{p}{gEI}}$ is the period of the natural vibrations of the bridge,

$T' = \frac{l}{v}$ the time taken by the load to cross the bridge,
$p$, the weight of the girder per unit length,
$v$, the speed of the load.

In the case under consideration at the

moment, the dynamic increment $\frac{\alpha}{1-\alpha}$ also diminishes, although slightly, with increase in the span. It is still not very great, however. In fact, at the very high speed of 108 km. (67 miles) per hour, that is, 30 m. (98 ½ feet) per second, for ordinary types of bridges, the increment calculated according to the above-mentioned formula would be about 12 % when the span is 20 m. (65½ feet) and about 9 % when the span is 120 m. (394 feet), that is to say, fairly limited. It must be pointed out, however, that when several loads act on the bridge, the resulting oscillations are only equal to the sum of the oscillations due to the different loads if these latter are synchronous; in the other cases they partly annul each other; consequently, in the practical case of several loads, the formula gives values which are generally too great.

It may hence be concluded that, even in the most unfavourable cases, the two effects — centrifugal force and vibrations — due to speed alone, give rise to a limited dynamic increment, not exceeding 10 %, except in the case of small, very shallow girders, for which the dynamic increase due to the centrifugal force may become fairly high.

It does not appear that any exact experiments have been made with the view of determining these effects. They would be easy to carry out, by working on a perfectly level track, with jointless rails, and using electric locomotives of a perfectly balanced type.

13. — *Dynamic effect due to « hammering » forces; hammerblow of the locomotive balance weights.* — Effects greater than those due to speed alone may be produced in certain cases by hammering forces to which the rotation of the unbalanced masses of the locomotive driving wheels gives rise.

Let $\frac{Q}{g}$ be the unbalanced mass of a wheel, $r$, the distance of its centre of gravity from the axis of the wheel, R, the diameter of the wheel, $v$, the speed of translation, and $\omega = \frac{V}{R}$, the angular speed of the wheel. The movement of the wheel gives rise to the centrifugal force $F = \frac{Q}{g} \frac{v^2}{R^2} r$;

and the vertical component F cos ($\omega t$) of this centrifugal force constitutes a hammering force which is added to the static load. On the average, for imperfectly balanced locomotives and at the ordinary speeds, it may be assumed that the value of F attains about 5 tons.

The effect of this force F may become very serious when a speed, called the critical speed, is reached such that the number of revolutions per second of the driving wheels is equal to the natural frequency of vibration of the bridge, because then the phenomenon of resonance is produced. For bridges of small span, the natural frequency of vibration, is so high that it is impossible for there to be synchronism between the periodic load and the natural vibrations. This synchronism can only exist and the resulting phenomenon of resonance can only be evident for spans greater than about 30 m. (98 ½ feet).

This phenomenon also has been fully considered by Professor Timeshenko. The method is somewhat complex, but the final result, under the conditions of resonance, may be enounced in a very simple manner.

If we denote by F the maximum pressure exerted on the rail by the balance weights, when the speed of translation is such that the driving wheels make 1 revolution per second; by $\frac{F}{T^2}$ the pressure when the number of revolutions per second is equal to the frequency $\frac{1}{T}$ of the natural vibrations of the bridge; by $n$ the total number of revolutions of the driving wheels during the crossing of the bridge; then the flexure of the bridge due to the balance weights at the critical speed for resonance is expressed by

$$f = \frac{2n}{T^2} \frac{2Fl^3}{EI\pi^4}$$

It will be seen that the increment depends upon three quantities: the static flexure $\frac{2Fl^3}{EI\pi^4}$ due to the force F, the period T of the natural vibrations of the span, and the number $n$ of the revolutions, none of which quantities enters into the ordinary formulæ for the dynamic increment.

According to this theory, the greatest effect is obtained with the smallest spans at which resonance becomes possible (about 30 m. [98 ½ feet] as stated above) because at these spans the critical speed as defined above is a maximum and consequently the hammering forces possess their greatest intensity. When the span increases, the natural frequency of the vibrations diminishes, consequently the critical speed also diminishes, and with it the intensity of the hammering forces.

This fact is the only one, as regards the effect in question, which agrees with the ordinary formulæ expressing the dynamic increment as an inverse function of the speed.

For the smallest spans which are capable of resonance, the dynamic increment, as given by Timeshenko's formula referred to above, would attain a very high figure, approaching 100 % of the static effect. Two remarks should, however, be made in this connection. The first is that with the locomotives actually in use, there is never one single hammering force, but several forces out of phase with each other and the effects of which therefore partly cancel one another. The second is that the natural frequency of the bridge (given by

$$\frac{1}{T} = \frac{\pi}{2l^2} \sqrt{\frac{gEI}{p}}\Bigg)$$

depending upon $p$, the weight of unit length of the bridge and upon the load, varies while the moving loads are passing over the bridge. The loads cannot, therefore, be in resonance during the whole of the period they are passing over the bridge, and for this reason their effects can never be as pronounced as the theory under discussion would lead one to believe.

Another circumstance hinders to a considerable extent the regular production of resonance, and this is the presence of the locomotive springs. When the oscillation of the bridge has reached a certain intensity, the springs come into action, and then it is not all the mass of the locomotive but only the unsuspended part which oscillates as a whole with the bridge. When the weight varies, the frequency of the bridge vibrations varies also, and consequently the critical speed is materially modified.

All these disturbing factors explain how in the experiments made by the « Indian Railway Bridge Committee » and in others carried out subsequently, the recorded effect never reaches one third

of that anticipated by the above-mentioned formula.

For spans below that at which resonance is possible, without the span being very small, the balance weight effect is much less; the formula relating thereto, expressing the effect of these balance weights by taking the vibrations into account, is rather complex, and for reasons of simplicity will not be reproduced here.

For girders of very small span, like the track stringers, the natural frequency of which is very high, the balance weight effect may be estimated by neglecting the vibrations. The calculation then becomes very simple: it is merely necessary to determine the action of the centrifugal force of the balance weights by means of the usual statical formulæ.

The action so far discussed, also termed the locomotive hammerblow, has been the subject of much experimental study.

Since 1910 long series of experiments have been made on this subject in America, India, and England, and it will be very interesting to read the report of this last English enquiry, recently concluded, and with which the writer has not yet been able to become closely acquainted.

In spite of all the reductions already foreseen by theory, it appears to result from these experiments carried out in the English-speaking countries, that the hammerblow may, in certain circumstances, produce very considerable effects.

It seems, therefore, that the conclusion has been arrived at, that in order to determine the stresses encountered in a bridge, the hammerblow effect should be explicitly considered, apart from the static load. The English Committee which has conducted the last experimental enquiry mentioned above has proposed, if the writer is well informed, the adoption of the following values: a total hammerblow of 5 tons at 5 revolutions per second for 3 or 4-cylinder locomotives; a total hammerblow of 10 tons at 5 revolutions per second for 2-cylinder locomotives; finally, a hammerblow of 15 tons at 5 revolutions per second for a certain number of 2-cylinder locomotives which are not very heavy, but are rather badly balanced.

The explicit consideration of a well determined hammering force, to take into account the hammerblow effect of locomotives, is, in the opinion of the writer, justified in principle and is worthy of being introduced into the current practice of bridge calculations. At the same time the writer considers that the intensities of these hammering forces, which ought to be determined by each administration, in correlation with the characteristics of their own locomotives, would vary considerably from one case to another.

In this connexion, the writer considers it an opportune moment to inform his readers that in numerous series of experiments made by the Italian Railways on two bridges, one of 40 m. (131 feet) span and the other of 50 m. (164 feet) span, using steam and electric locomotives, at speeds increasing successively by 5 m. (16 ft. 5 in.), the hammerblow effects were not very appreciable. At the critical speeds, the increment of the inflexion was never found to be greater than 8 %, and the steam locomotives gave results differing by very little from those of perfectly balanced electric locomotives. These facts agree with the observations made some years ago by the Swiss Railways.

The hammerblow to be taken into

consideration in bridge calculations may, therefore, under the conditions of the experiments just mentioned, be regarded as having a much smaller intensity that those proposed by the English Committee.

It should however be pointed out at once that the locomotives used in the experiments made by the Italian Railways were modern and very heavy but well balanced.

To check the results, the experiments will be continued by purposely unbalancing the same locomotives in known proportions, and by employing locomotives which are not so well balanced.

14. — *Dynamic actions due to irregularities in the track and the locomotive tyres.* — A third series of dynamic actions which has very important effects, particularly on short girders, is that due to irregularities in the track and in the locomotive tyres.

The tyres are not always perfectly circular, but possess flat places here and there; the rails, on their part, may be locally out of the level, due to irregular wear. Most frequently local depressions, of very small length, are produced in the rail while the loads are passing or by the presence of joints or because there is a badly packed and loose sleeper in a series of sleepers which are otherwise all well packed and maintain the track at a uniform level.

For all these reasons, the wheels, at certain points, are allowed to drop, almost suddenly, which gives rise to an intense dynamic action.

If the depression in the rail, or the flat part of the tyre have the shape of a flat curve, the additional dynamic pressure is easy to determine. Let $l$ be the length of the depression, $\delta$ its depth, $v$ the speed of the load, $P$, the fraction of the unsuspended weight.

The additional pressure will be

$$P' = \frac{P}{g}\frac{4\pi^2}{l^2}\frac{\delta v^2}{2} = \frac{P}{50}\frac{\delta}{l^2}v^2,$$

showing that it is proportional to the unsuspended mass, to the square of the speed, and the ratio $\frac{\delta}{l^2}$. If the depth was 5 mm. (3/16 inch) on a length of 1 metre (3 ft. 3 3/8 in.), at the speed $v = 36$ km. (22.4 miles) per hour = 1 000 cm. per second, the additional pressure would be equal to the weight of the unsuspended mass; at the speed v = 108 km. (67 miles) per hour = 3 000 cm. per second, it would be nine times as great. All this of course on the assumption that the track on the bridges is rigid, *i. e.* neglecting its flexibility.

It will be seen, therefore, that the effect may be very intense. In some cases, it may become greater than that resulting from the analysis indicated above, and for two reasons:

1. Because, for example on passing over the rail joints, the dynamic effect in question may be accompanied by shock effects, properly so-called;

2. Because, when the blows are periodic, like those produced on passing over the rail joints or like those due to flattened portions of the tyres, they may be synchronous with the natural vibrations of the girder, and give rise to resonance phenomena.

This last fact does not only correspond to a theoretical induction, but has also been found experimentally and formulæ have been proposed to take this into account.

Since the dynamic effects of the class which we are considering at the moment are closely bound up with the upkeep

conditions of the rolling stock and the permanent way, conditions which may differ in a marked manner from one administration to another, they ought to be studied experimentally, in each case, by these administrations.

The experimental research does not offer any difficulties, if the precaution is taken to employ perfectly balanced locomotives, so as to introduce the minimum possible disturbing factor. Whatever may be the results of this research, however, and since it is certain that the effects in question may become very serious for very short main girders and for floor beams, the writer considers that efforts should be made to eliminate these effects, provided also that this may be done fairly easily, at least as regards the track irregularities.

Consequently, it would appear desirable to lay down that only rails in perfect condition, absolutely free from local depressions, should be retained on bridges; that particular care should be paid to the conditions under which the sleepers are laid; and above all, also, it appears advisable to eliminate rail joints on bridges, by means of welding.

15. — *Influence of the ballast on the dynamic effects.* — The different organic constitution of bridges may exert an influence on the intensity of the effects produced by the various dynamic actions. The element which, in this connection, appears to be of the greatest importance, is the means intended to support the track directly It is therefore interesting to know if, from the point of view of dynamic actions, there are advantages, and what they are, in laying the track on ballast, as in the open line, instead of laying it on sleepers fixed to track stringers.

The question still appears to be a debated point. Experiments carried out in different places, especially those of 1921 in England — the writer is unacquainted with the most recent — have failed to bring out any essential differences between the two methods of laying the track.

Recently Professor Beljaeff carried out theoretical and experimental researches on some Russian bridges, and came to the following conclusions which contain some definite points.

He recognised that the two main actions to be taken into consideration in determining the influence of the ballast are the action of the locomotive balance weight and the action of impact on passing over the rail joints. He found also that ballasted bridges, being to a marked degree heavier, are in better conditions as regards the first action; and on the contrary, since the ballast provides a more rigid support to the track than sleepers fixed to track stringers, these bridges are less favourably situated as regards the second action.

It appears to have resulted clearly from the experiments that the dynamic coefficient is greater with track laid on sleepers when extremely ill-balanced locomotives are passing over the bridge, while under vehicles or balanced locomotives, or complete trains, that is to say, in all cases where the effect of the ill-balancing of the locomotive balance weights makes itself less felt and where the action of the joints predominates, the dynamic coefficient is less when the track is laid on sleepers.

The practical consequence would be that the use of ballast is effectively suitable, provided it is accompanied by the elimination of the rail joints by welding, and that the use of sleepers does not result in an inferior state when the train

service is operated by well-balanced locomotives.

The question is still worth considering, and the influence of the ballast should not be lost sight of in the experiments to be carried out for the purpose of examining the different dynamic actions.

16. — *The dynamic behaviour of bridges as an indication of their state of preservation; determination of the characteristics of the free oscillations by means of vibrating machines.* — Up to the present we have considered the dynamic actions in so far as they give rise to an increment of the inflections and stresses, as compared with the static loads. The dynamic behaviour of a bridge, however, may be examined from another point of view, namely, as an indication of the state of preservation of the structure.

At the present time, we have no sufficiently certain criterion which will tell us what is the intimate state of preservation of a steel bridge, and whether the time has come to withdraw it from service, independently of the increase in the loads. Very close inspection may reveal local deterioration, but generally it is not possible to attribute this to the fatigue due to a long period of service; and in any case, what might be the most serious consequences of this fatigue, that is to say, an eventual alteration in the quality of the steel, and the breaking down of the riveted joints, remain unknown.

Some regulations lay down that tests should be made periodically, with the obvious intention of ascertaining whether with the lapse of time there has been a reduction of the general modulus of elasticity of the bridge, and consequently a modification of its intimate structure. Since, however, these tests cannot be made, at intervals of years, with the same load, the variation in the modulus of elasticity has to be deduced by comparing the theoretical flexures with the actual flexures, determined under different loading conditions each time; consequently, the determination is practically always extremely uncertain.

A considerable progress would be effected if each administration could have at its disposal the vehicle mentioned in Section 8, with which the load may be concentrated on a single axle, and could determine very exactly the experimental lines of influence. By comparing these experimental lines of influence, determined at intervals of years with the same concentrated weight, it would be possible to obtain much more certain information than the comparison of flexures measured under trains having always a different composition.

It would appear, however, that still greater progress could be effected by making use of the systematic examination of the dynamic characteristics of the bridge, and more precisely, the examination of the characteristics of the free oscillations.

The amplitude of these oscillations, their period, and to a still more marked degree, their rate of damping are closely bound up with the internal friction of the steel due to the modification in the state of its riveted joints. It is to these riveted joints that the hysteresis in the elastic behaviour of the entire structure is mainly attributed. These characteristics of free oscillations may vary with the time and numerous experiments carried out with the statical method by the Russian railways show that they actually do vary. It has been found, in fact, that in old bridges, the period of vibra-

tion increases in relation to a reduction in the general modulus of elasticity of the bridge. It was found, moreover, that the damping period, defined as the time required for the amplitude of the oscillations to be reduced to one-tenth part of its maximum initial value, diminishes in old bridges.

It will thus be understood how useful it is to examine the dynamic behaviour of a bridge in order to obtain information regarding its intimate constitution and the eventual changes taking place with time, which agrees with the practice adopted in laboratories for testing building materials, where, apart from the ordinary static tests, dynamic tests of various kinds are always made.

There does not seem to be very much use to enter into details regarding the technique of the oscillations of bridges. It may merely be pointed out that the oscillations produced when a locomotive or a train passes over the bridge constitute a very complex problem, closely connected with the nature of the load, while for the purposes of this Report, the phenomenon must be reduced to its simplest expression and merely depends upon the oscillating system constituted by the bridge.

To obtain these conditions, the experiments made in Russia, referred to above, were carried out by allowing a cast-iron weight to fall on the bridge from a height of 1 to 2 m. (3 ft. 3 3/8 in. to 6 ft. 6 3/4 in.) and observing the free oscillations set up in this fashion.

The same result may be obtained, and in a more complete manner, by means of a special oscillator apparatus, which was employed in the last series of experiments by the English Committee, the use of which has also been introduced into Germany.

It consists essentially of two discs to which are secured eccentrically two heavy weights, and which are mounted on two parallel shafts driven by an electric motor. By rotating the two shafts in the same direction or in contrary directions, and by varying the speed of rotation and the position of the eccentric weights, it is possible to impress on the bridge absolutely definite horizontal or vertical impulses of variable intensity and rhythm.

By the aid of machines of this type, it is possible to determine with every desirable exactitude, the oscillation characteristics of a bridge, and hence to obtain a series of precise data, which may be used for two quite distinct objects :

1. to provide a starting point for a study of the most complex actions due to locomotives and trains; 2. to obtain, at a definite moment, information regarding the bridge intended to serve as a basis of comparison for determining at successive intervals of time, if and in what manner, the elastic conditions of the bridge vary and with them its elastic state.

The writer considers that determinations of the oscillation characteristics made with vibrating machines have the same value for dynamic stresses as the determination of the experimental lines of influence by the use of special vehicles with one bearing axle has for the static stresses.

In this connexion, it may be noted further that the vibrating machine could be mounted on this vehicle with one bearing axle. In this way would be obtained a unique appliance of the utmost importance for the experimental study of bridges.

Rome, June 1929.

[ 656. 25 ]

# REPORT No. 2

**(All countries except America, the British Empire, China, Japan, Belgium, France, Italy, Portugal, Spain and their Colonies)**

## ON THE QUESTION OF SIGNALLING OF LINES FOR FAST TRAFFIC AND IN MAIN STATIONS. DAYLIGHT SIGNALS. AUTOMATIC BLOCK SYSTEM (SUBJECT XI FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1),

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Figs. 1 to 70, pp. 3163 to 3209.

## CHAPTER I.

### Introduction.

The list of questions relating to question XI was sent to the Member Administrations of the Association in the undermentioned countries :

Denmark, Norway, Sweden, Finland, Holland, Luxemburg, Switzerland, Czechoslovakia, Poland, Rumania, Yugoslavia, Bulgaria, Greece, and Egypt.

Of the 51 administrations who were consulted, 32, or 63 %, replied, and of these 32, 17 stated that, owing to special conditions prevailing on their lines, they were not able to provide any useful information.

If the systems in question are given in kilometres we find that the 51 administrations consulted have a total of 92 563 km. of lines, of which 49 717, or 54 %, belong to the administrations who have given information, while 6 461 km. of lines or 7 % belong to administrations who have no useful information to impart, and 3 % to the administrations who have not replied.

The replies have been completed by data from the press and technical publications. As regards Germany, observations have also been made on the spot. It has been thought useful to give a fairly detailed description of the German systems, despite the fact that this country does not belong to the Association (1), because several countries, who are Members of the Association, have adopted signalling systems which are, so to speak, derived from German systems (2).

(1) Translated from the French.

(1) At the time this report was written. The German Government and the German Railways are now Members of the International Railway Congress Association, and a special report dealing with this question as far as Germany is concerned is now being prepared and will be published in the usual way in the *Bulletin* before the Madrid session.

(2) Vide particularly SCHNEIDER and GOTTER : « Die deutsche Eisenbahn- Signalordnung (1927) », W. CAUER, « Sicherungsanlagen im Eisenbahnbetrieb (1922), E. SCHUBERT and O. ROUDOLF, « Die Sicherungswerke im Eisenbahnbetriebe (1925) », E. H. HENTZEN, « Das Einheitsstellwerk (1927) », « Eisenbahn Bau- und Betriebsordnung (1928) », « Preussisch-Hessische Staatseisenbahnen : Signalbuch mit später eingetretenen Änderungen », « Kgl. Bayer. Staatseisenbahnen Signalbuch (1907) ».

The report is divided into chapters corresponding to the headings set forth in the title. The first heading « Signalling of lines for fast traffic and in Main Stations », however, has been subdivided into three Chapters (II to IV), the first of which (Chapter II) contains general information concerning the method of operation, the maximum speed, the visibility, the types of block system adopted on the various systems and the indications on the extent of the lines operated on the block system, the average length of the block sections, etc. In the next two Chapters (Chapters III and IV), a brief description is given of the systems of signalling employed to protect a station, a junction, a section, etc. on lines for fast traffic and at main stations excepting lines with automatic block systems, on which the principles of signalling often differ from the principles applied on other lines. In the last chapter (Chapter VII) are given some general considerations based on the comparison between different signalling systems, and the automatic block system.

After studying the information received in reply to the questions relating to the descriptions of the various systems, the opinion has been formed that, usually, the signalling system of a country does not form an indivisible whole, but that many of these systems are conglomerates of which the parts are derived from different systems. It is not easy however to see where one is in the numerous descriptions of signalling in different countries, when these descriptions are detailed according to the railway systems. That is why it has been considered necessary to classify them according to the various cases : signalling into section, signalling out of section, etc., cases which are so to speak identical in all countries with fast traffic, and the different solutions adopted on the different railways have been given under these headings. By employing this method, the intention was to avoid unnecessary repetition, and it is hoped that the report has thereby gained in clearness.

## CHAPTER II.

### Generalities, speed, visibility, and block system.

#### A. — Generalities.

The chief aim of a system of signalling is to provide the engine driver with information telling him whether he has to stop at a definite point, whether he has to slow up, or whether he may continue without slackening speed. A system of signalling depends always upon the maximum speed of the trains, the braking distance, and the visibility of the signals employed.

Originally the solution of the problem presented no difficulty, because the trains always ran at a fairly slow speed, and consequently it was easy to obtain the necessary visibility by using one signal alone in front of a dangerous point — semaphore or disc signal with two positions, and at night a lamp with two different indications: line occupied, and line clear.

With the increase in the weight and speed of trains, the problem has become complex, and different methods have been applied on various railway systems to obtain the necessary visibility.

Even though it might be possible to find an exact formula expressing the relationship between the speed, the braking distance, and the visibility, it would not be possible to use such a formula as a basis for a signalling system which would give satisfaction in case of bad weather. Consequently, on most rail-

ways, for fast traffic lines the protecting signal has been doubled by a distant signal generally placed at a distance varying with the braking distance. The rules regarding the position of distant signals are given in Chapter III.

B. — Speed.

The maximum speed and the speed on branch lines vary considerably on different railway systems. Particulars regarding this are given in the following table :

| — | *Maximum speed* | *Speed on a branch line* |
|---|---|---|
| Czechoslovakia . . . . | 90 km. (55.9 miles) (provisional maximum speed). | 30 km. (18.6 miles) (passenger trains). 20 km. (12.4 miles) (goods trains). |
| Switzerland . . . . . | 90 km. (55.9 miles) (passenger trains). 75 km. (46.6 miles) (goods trains). | 40 km. (24.8 miles) (trains with compressed air brakes). 30 km. (18.6 miles) (hand-braked trains). |
| Germany. . . . . . | 120 km. (74.6 miles) (exceptional maximum speed). 100 km. (62 miles) (normal maximum speed). | according to local regulations. |
| Luxemburg . . . . . | 100 km. (62 miles). | 45 km. (28 miles) (passenger trains). 30 km. (18 6 miles) (goods trains). |
| Yugoslavia . . . . . | 80 km. (49.6 miles). | 40 km. (24.8 miles) (60 km. (37.3 miles) on straight line). |
| Sweden . . . . . . | 90 km. (55.9 miles). | 40 km. (24.8 miles) (may be increased when special points are used). |
| Finland . . . . . . . | 80 km. (49.6 miles) (passenger trains). 65 km. (40.4 miles) (goods trains). | 35 km. (21.7 miles). |
| Norway . . . . . . . | 80 km. (49.6 miles). | 25 to 60 km. (15.5 to 37.3 miles) (varying according to the radius of curve, the locking of the points, etc.) |
| Egypt. . . . . . . . | 80 km. (49.6 miles). | The driver must reduce the speed so as to be able to run over the points with every safety. For many stations more detailed information is given in the time-table. |
| Holland . . . . . . . | 95 km. (59 miles) (electric trains). 90 km. (55.9 miles) (other trains). | 45 km. (28 miles). |
| Denmark. . . . . . . | 90 km. (55.9 miles). | 45 km. (28 miles). |

### C. — Visibility.

The signals are painted a suitable colour to make them stand out from the background. The arms and masts of sempahore signals are usually painted red and white. The background is also taken into consideration in selecting their position.

Generally no definite visibility is laid down for different signals, except as regards the Swedish State Railways, the Czechoslovakian State Railways and the Luxemburg Railways. Although a minimum has been laid down, the signals are usually visible for a much greater distance.

On the Swedish State Railways, the distant signal must be visible from a distance of 200 m. (656 feet), and efforts are made to select its position such that the home signal can be seen the moment the distant signal is passed.

On the Czechoslovakian State Railways a minimum visibility of 200 m. (656 feet) has been laid down for the home signal, and 150 m. (492 feet) for the distant signal.

On the Luxemburg Railways a visibility of 10 seconds has been laid down for distant signals. When this visibility cannot be attained, two warning posts, painted in alternate red and white bands are set up at a distance of 30 m. (98 1/2 feet) apart and lit up at night.

On the Swiss Federal Railways the distant signals are repeated if they cannot be placed so as to give sufficiently good visibility.

In Finland the distant signals may be omitted if the visibility of the home signal is at least 500 m. (1 640 feet).

On the Danish State Railways, the distant signals preceding the home signals are generally placed so that the home signal can be seen the moment the distant signal is passed. The distant signals are not repeated, even when it is impossible to obtain this visibility.

On almost all electrified railways, the overhead lines and the posts are detrimental to the visibility of the signals. In some countries, Holland and Switzerland, for example, where 60 % of the railways are electrified, this drawback is not considered important enough to warrant considering other forms of signals, but on other railways, in Sweden for example, where 7.52 % of the State Railways are electrified, in Norway, and in Czechoslovakia, an attempt has been made to counteract the effect by substituting daylight signals for signals with movable arms.

### D. — The block system.

Originally, many railways employed « time interval » systems, that is to say a train could be sent away for example five minutes after the start of the preceding train, the driver being warned. After an interval of ten minutes the line was considered to be clear.

Nowadays the « time interval » principle has been abandoned on all lines for fast traffic and, on the railways considered in this report, the absolute block system has been adopted, that is to say, a certain distance is maintained between trains by dividing the lines into sections, and not allowing more than one train to be in one section at the same time (with the exception of lines on the automatic block system — see Chapter VI). On most lines this distance is that between the stations, and the trains are worked by telegraphic messages between the stations.

When traffic increases, it may become impossible to maintain this distance between the trains and it may be necessary to divide the interval separating two

stations into smaller sections. The simplest form is used in the Czechoslovakian State Railways, where there are 1 700 km. (1 056 miles) of line with telephonic control. The lines in question are divided into block sections by signals which are independent of one another and equipped with telephonic communication so arranged that communication is only possible between two neighbouring signal boxes, and if need be with the next station. The call signals and replies are repeated successively from one signal-box to another. On many railways, by means of a block system, inter-dependence has been established between the line signals, including the home and starting signals. Usually, this inter-dependence is effected by a manually controlled block system while a small number of railways have adopted automatic block systems, a detailed description of which will be given in a special chapter.

As regards the manual controlled block system, it is considered that a full description is beyond the scope of this Report, and for that reason the outline given merely contains the information which has been thought necessary to explain the block system of signalling.

On most of the railways dealt with in this report, the Siemens and Halske alternating current system has been adopted with very few modifications, excepting as regards Egypt where Tyers instruments (double line) and the « Railway Signal Company's Electric Staff » (single line) are used, and as a typical example a description is given of the system used in Switzerland.

The principal feature in working consists of block instruments, the operation of which enables a mechanical locking to be effected on the spot and an electrical release from another block station. Owing to the fact that each block instrument is connected with the signal levers, the signals may be locked by means of the block instrument, and released electrically from another block station. In carrying out the various operations, there are conditions of inter-dependence ensuring their taking place in the prescribed order.

Whether each block section is clear or closed in either direction is indicated at the departure station by the starting block instruments, and at the arrival station by the end block instrument. These instruments are connected together by electrical leads, and the necessary current is produced by a hand-operated inductor. A white indicator behind a glass window signifies « traffic authorised » (line clear); the red indicator signifies « traffic forbidden » (line engaged).

When a section is blocked, the following conditions obtain:

The starting signal on a section can only once be set at « line clear » (intermediate and repetition locking); the signal is set at « danger » automatically (mechanically or electrically) by the train itself.

Once it is replaced, the signal lever locks itself.

The starting block instrument must be operated and its indicator becomes red, the signal lever is then locked by the block which comes into action in place of the repetition lock. At the same time the train is announced on the end instrument of the following block station, the indicator of which changes from white to red.

The end block instrument, once the train has entered the section, can only be operated once, provided that the lever of the home signal has been set once at « line clear » and at « danger », and that the train has passed over a rail contact. By this operation, the indicator of the

end block instrument again shows white, the starting instrument of the preceding block station is unlocked and also its indicator shows white, the lever of the home signal being released for a fresh operation.

When several home or starting signals belong to the same main line, they are all dependent upon the same block instrument. Only one signal lever can be operated at a time in the same direction. Consequently, without a preliminary operation of the block, no other of these starting or home levers can be operated.

On block sections where trains pass without stopping, and where there are no shunt-backs or passing loops, the final block instrument, and the starting block instrument for the same direction are provided with a common plunger-key, ensuring that the two block instruments will be operated simultaneously.

On single line railways where the block system is employed, the starting instrument of the end stations (stations where the trains are made up, where their run ends, or where they may be passed or shunted back) is normally blocked even though there is no train in the block section, its indicator is red, and the lever of the starting signal is locked. To set the starting signal at « line clear », authorisation must be given by the station at the other end of the section. The terminal stations are consequently provided with another block instrument, that is, an authorising instrument.

If the section of a single-line railway is subdivided by an intermediate block station, authorisation may be given for a second train to follow on in the same direction, once the first train has passed the first block subdivision, and is protected by the block signal of the second block subdivision, in other words, once the intermediate station has operated the instrument, and blocked the line ahead and cleared the line behind.

The intermediate station, like those of the double line railway, possesses a starting instrument and an end instrument connected by a common plunger-key.

Intermediate block stations and the less important end block stations are provided with a device enabling the instruments to be put out of action when traffic is not very heavy (at night and on Sundays), and when it is not necessary for signalmen to be present. The signals of these block stations are set at « line clear » while the corresponding instruments are out of action, and the instruments of the two adjacent stations are connected together directly.

In the table on the opposite page a summary is given of the lengths of line operated on the block system. The table shows that, on some railways, as in Switzerland, the block system has been introduced on a relatively large portion of the lines while it has not been used much on other railways, for example, in Sweden, in Luxemburg, etc.

The necessity of introducing a block system must not be considered as a logical result of the speed of the traffic, but of its frequency. On most railways, the principle has been adopted that the portion of the line situated between the home signal of a station and the starting signals of the same stations forms a neutral section such that the block section begins with the starting signal of one station and ends with the home signal of the following station. By adopting this principle it is possible to clear the section when the train has entered the station. On some railways the block is arranged in such a way that a train standing in secondary stations prevents the section from being clear. The first of the abovementioned methods is employed in Cze-

| STATE RAILWAYS. | Length of lines with fast traffic. | | | | | Total length. (Miles.) | Percentage of total length formed by length operated on block system. |
|---|---|---|---|---|---|---|---|
| | Non-automatic block system. (Miles.) | Automatic block system. (Miles ) | Semi-automatic block system. (Miles.) | Lines operated on block system. (Miles.) | Lines not operated on block system. (Miles.) | | |
| Czechoslovakia. . . . . . . | 757.5 d. l. (1.86) 236.1 s. l. | ... | ... | 994 | 117 d. l. 2 790 s. l. | 7 723 | 12.9 |
| Switzerland . . . . . . . . | 344.2 d. l. (1.24 to 3.1) 62.8 s. l. | ... | 18 | 425 | ... | 1 909 | 22.3 |
| Luxemburg . . . . . . . . | 18,6 d. l. (1.24 to 2.8) | ... | ... | 18.6 | ... | 128.6 | 14.5 |
| Yugoslovia. . . . . . . . . | 26.1 d. l. (1.5 to 2.9) 55.9 s. l. (0.62 to 1.86) | ... | ... | 82 | 1 932 | 5 595 | 1.5 |
| Sweden . . . . . . . . . . | 148.5 d. l. (0.62 to 5.0) | 6.8 d. l. (0.62 to 0.74) 7.5 s. l. (5.0 max.) | ... | 163 | 1 127 | 3 762 | 4.3 |
| Finland . . . . . . . . . . | 3.7 d. l. (0.62 to 1.6) 3.7 s. l. (1.55 to 1.86) | 2.23 d. l. (0.37 to 1.30) | ... | 97 | 91.3 d. l. 298 s. l. | 2 834 | 0 3 |
| Norway . . . . . . . . . . | 10,6 d. l. 13.7 s. l. | ... | 2.5 d. l. 30.4 s. l. | 57.2 | ... | 2 025 | 2.8 |
| Egypt . . . . . . . . . . . | All lines for fast traffic (612 miles) are provided with non-automatic block system. | | | | | 2 254 | 30.5 |
| Holland . . . . . . . . . . | 1 230 d. l. (0.43 to 1.86) 171 s. l. | 14.3 (1.86) | ... | 1 415 | ... | 2 006 | 62.8 |
| Denmark. . . . . . . . . . | 170.9 d. l. 12.4 s. l. | 3.4 | ... | 145.1 | 208 d. l. 90 s. l. | 1 649 | 8.9 |

d. l. = double line. — s. l. = single line. — The figures in brackets indicate the length of a block section.

choslovakia, Germany, Yugoslavia, Sweden, Finland, Denmark, and Egypt. In Switzerland it may happen that a station of little importance is placed between two intermediate block stations, and is protected merely by signals independent of the block signals so as to enable better splitting up of the sections.

## CHAPTER III.

### Position, description and designation of signals on lines for fast traffic.

The various systems of signalling dealt with in this Report may be classified under three groups: the systems of Central Europe (Germany, Norway, Finland, Luxemburg, Switzerland, Czechoslovakia, and Yugoslavia), the English system (Egypt), and the intermediate systems (Denmark and Holland).

#### A. — Signals for entering a station.

As a general rule applied to all the lines dealt with in this report a station is protected by a home signal usually preceded by a distant signal.

##### a) Location of the home signal.

In all the above-mentioned countries the usual type of signal employed is a semaphore signal which in the normal position is at danger. This signal cannot be passed, that is to say, every train must stop, without exception, before the signal, which it must not pass without special authorisation. The location and type of this signal differ on the various railways.

In the following account information is given regarding the location normally adopted, no account being taken of the exceptions existing on various lines where, to meet special conditions, it has been thought necessary to depart from the general rule.

When the home signal is placed at the side of the corresponding track, there are four possible positions in which semaphore signals may be located (see fig. 1 *a* to *d*):

1) Traffic on the right hand track, the arms pointing to the right (Denmark, Norway, Holland, Germany, Luxemburg) [excepting one line of 18 km. (11.2 miles)], Switzerland (solely on single lines), Czechoslovakia (excepting two old lines), Yugoslavia [except on a line of 219 km. (136 miles)].

2) Traffic on the right-hand track, the arms on the left (Finland);

3) Traffic on the left-hand track, the arms on the right (Luxemburg, a line of 18 km., Switzerland on double lines only, Yugoslavia, one line only of 219 km.);

4) Traffic on the left-hand track, the arms on the left (Sweden and Egypt).

The distance at which the signal is placed varies considerably in the different countries. Below, the distance between the home signal and the first points is given, but the figures are only approximate, and the various railways allow exceptions, where local conditions demand it:

Czechoslovakia : 200 m. (656 feet) minimum;

Switzerland : 200 to 300 m. (656 to 984 feet);

Germany (except Bavaria): 50 m. (164 feet) minimum;

Bavaria: 100 m. (328 feet) (minimum);

Luxemburg: 50 m. (164 feet) (minimum, on single lines the distance may be increased to 200 m. [656 feet]);

Sweden: 200 m. (656 feet). On some private lines: 50 m. (164 feet);

Yugoslavia: 100 m. (328 feet) (minimum : if the signal is not preceded by a distant signal the distance may be extended to 200 m. [656 feet]);

Fig. 1.

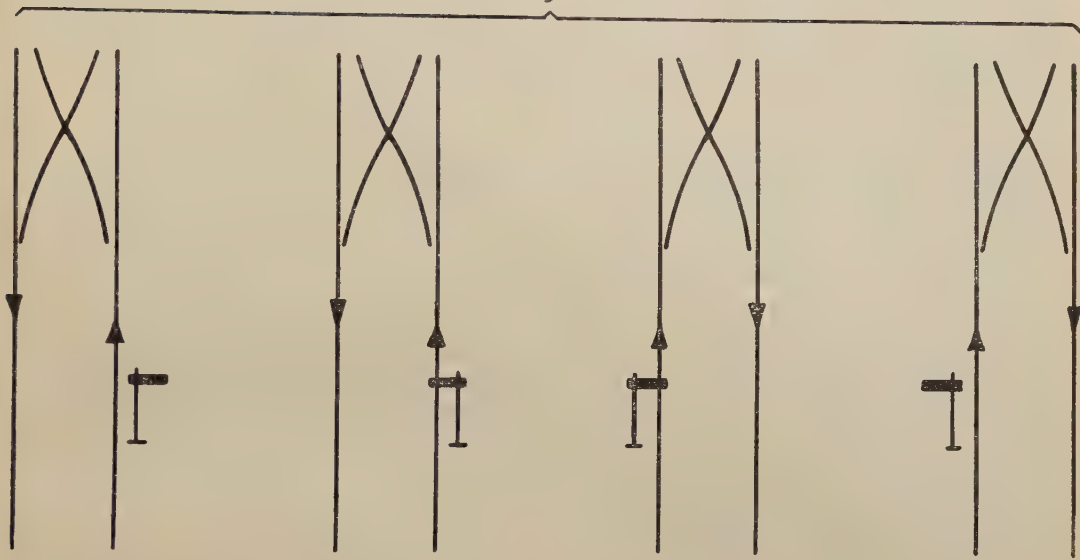



Fig. 1. — Position of home signals.

Finland: 250 to 500 m. (820 to 1 640 feet);

Norway: 200 m. (656 feet) (minimum);

Egypt: immediately in front of the points;

Holland : 100 m. (328 feet);

Denmark : 100 m.(328 feet) (minimum, usually the distance is 250 to 300 m. [820 to 984 feet]).

On various railways, trains shunting out of the station may advance as far as the home signal set at « danger », as in Sweden, Finland, and Switzerland (only when no train has been announced from the next station).

On other railways, there is a shunting limit situated between the home signal and the first points, as in Holland, Luxemburg, Czechoslovakia, Germany, Switzerland, and Denmark (the distance of the home signal from the limit is 50 m. [164 feet]) and in Norway (the distance is 20 m. [65 ft. 7 in.] but the trains must stop 20 m. in front of a signal set at « danger »). The limit is sometimes marked by a special post (for example in Luxemburg, Czechoslovakia, Germany, and Denmark).

b) **Location of the distant signal.**

On all railways with fast traffic a distant signal is usually placed in front of all home signals.

Usually this signal is placed on the same side of the track as the corresponding home signal. The distance between the main signal and the distant signal varies considerably. As a general rule, an endeavour is made to place the distant signal at the braking distance in front of the home signal. Consequently, the distance varies with the speed of the traffic and the gradient of the line. This

rule applies to the following countries, for which the distance limits are given:

Czechoslovakia : 400 to 700 m. (1 312 to 2 296 feet).

Switzerland : 400 to 600 m. (1 312 to 1 968 feet).

The signal may be repeated so as to obtain a better visibility.

Germany (excepting Bavaria): 400 to 700 m. (1 312 to 2 296 feet).

Bavaria: 350 to 700 m. (1 148 to 2 296 feet).

Luxemburg: 400 to 900 m. (1 312 to 2 953 feet).

Sweden: 500 to 700 m. (1 640 to 2 296 feet).

The distance may be reduced where the speed of the trains is always low and may be increased so as to obtain a better visibility (minimum visibility of 200 m. [656 feet]).

Finland : 250 to 800 m. (820 to 2 624 feet). This distant signal is always employed when the visibility of the home signal is less than 500 m. (1 640 feet).

Norway : 300 m. (984 feet) minimum.

In the three following countries, a distant signal is always placed at a fixed distance in front of the home signals:

Egypt : 750 m. (2 460).

Holland: 500 m. (1 640 feet).

This distance has recently been increased to 700 m. (2 296 feet). The distance is independent of the speed of the traffic and the gradient of the line.

Denmark: 400 m. (1 312 feet).

The distance is independent of the speed of the traffic and the gradient of the line.

**c) Description and design of the signals.**

The signal consists of a post, usually 8 to 12 m. (26 ft. 3 in to 39 ft. 4 ½ in.) high, provided with one, two, or three arms. The figures show the various types of signals diagrammatically, and the following is a brief description of them.

*1. The Central European systems.*

As a typical example of the system of signalling employed in Central Europe, the home signals of the Swiss Federal Railways have been given in figures 2*a-c*. Posts with one or two arms of rectangular form are used, the arms terminating in a sector of a circle [length 1.5 to 1.8 m. (4 ft. 11 in. to 5 ft. 10 7/8 in.), width 0.225 to 0.250 m. (8 7/8 to 9 13/16 in.), diameter of the sector 0.30 m. (11 13/16 in.)] and a corresponding number of lamps at night.

The semaphores are used to give the following signals:

— *the train must stop at home signal* : during the day, the arm (the upper arm) to the right of the post as seen from the train is horizontal, at night a red light on the same side of the train (see fig. 2*a*). If the signal carries more than one arm, the other arm is placed vertically out of sight.

— *Permission to enter station on the main line:* during the day, the arm (the upper arm) to the right of the post as seen from the train, is raised obliquely at an angle of 45°, at night a green light on the same side of the train (fig. 2*b*). If the signal carries more than one arm, the other arm is placed vertically out of sight.

— *Permission to enter station on a branch line:* during the day, the two arms as seen from the train are raised obliquely at an angle of 45°, at night two green lights on the same side of the train (fig. 2*c*).

In front of stations, etc. where there is only one arrival line and where,

consequently, it is not necessary to set the home signal for a branch line, the signal may be replaced by a disc signal (fig. 3 *a-b*). The following indications may be given by this signal:

— *the train must stop at home signal :* during the day, the red face of the disc with a diagonal band, at night, a red light (fig. 3*a*).

— *Permission to enter station:* during the day, the disc effaced (horizontal), at night a green light (fig. 3*b*).

In Germany (Bavaria excepted) the same form of semaphore is used for the day signals and for the lights, the size of the arm merely differs a little from that of the arm used in Switzerland. On the German railways, there are lines where the three-armed signal has never been used. On these railways, the arrival for all branch lines is indicated by the two-arm signal. On other German lines three-arm signals are used so as to be able to indicate with two or three arms, or with two or three lights, respectively the arrival for two different branch lines.

The Luxemburg railways use the same home signal (semaphore type) as Germany.

The system used in Bavaria (shown in figs. 4*a-c*) differs rather appreciably from the system normally adopted in Germany. Two-arm signals only are used. As will be seen from the figures the upper arm has not the ordinary form, but is pointed; the lights also are different.

« Danger » is indicated by a horizontal arm (a red light) (fig. 4*a*), permission to run in on a main line by one arm (the upper arm) raised obliquely upwards, the other arm being placed vertically out of sight (a white light) (fig. 4*b)*, and permission to run in on a branch line is represented by two arms raised obliquely upwards (at night a white light above a green light) (fig. 4*c*) [1]. Very often the home signal has been combined with the distant signal for starting signals, but the description of the starting signals is given in paragraph B, — starting signals.

The Finnish State Railways employ the same signal as Switzerland, but with the arms pointing to the left (figs. 5*a-c*). Very often flashing-lights are used for one-arm signals, when the background is bad for visibility, when the signal is not controlled, and when the normal position is at « line clear ». There are also a limited number of two-arm signals, in which flashing-lights are used, so as to indicate arrival on the main line by one green flashing-light and arrival on a branch line by two fixed green lights.

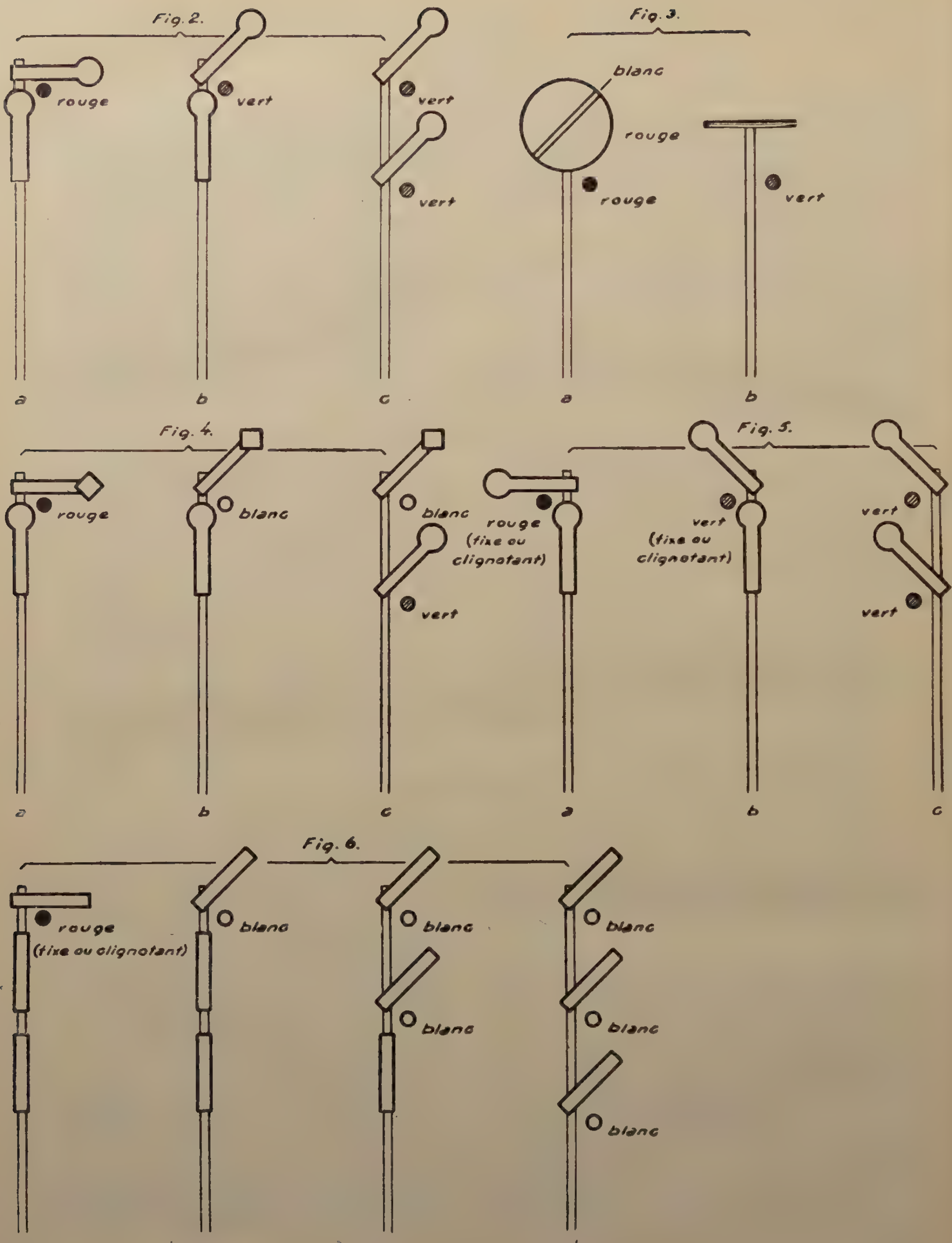
The Swedish State Railways employ the same signal with the arms (one, two, or three arms) on the left hand side. On these railways, the red light also may be flashing. The green lights are always fixed.

The railways of Yugoslavia employ the Swiss home signal without any modification.

The system of signalling used on the Czechoslovakian State Railways differs in certain respects from the Swiss system. The arms are rectangular (fig. 6 *a-d*), and the green light is replaced by a white light. In addition the three-arm signal is used when alongside the line entering the main station — passenger station — there is another line leading into a secondary station (sorting station, goods station, etc.).

The home signal of Central Europe is also used by the Norwegian State Railways, but the signal never carries two

(1) In recent years, the white light has been done away with, and thus the same night signal obtains as in Germany.




Figs. 2 to 6. — Home signals (system of Central Europe).

*Explanation of French terms* : Rouge = Red. — Vert = Green. — Blanc = White.
Fixe ou clignotant = Steady or flashing-light.

arms, and the various positions of the signals have a different meaning from the usual one:

— in the danger position (fig. 2*a*) red flashing-lights are always used;

— permission to run in on the main line is shown by two arms raised upwards obliquely (fig. 2*c*), and on the branch line by one arm raised upwards obliquely (fig. 2*b*), or two steady green lights and one steady green light, respectively.

In this way the disadvantage arising from the adoption of the home signal as used on other railways is obviated. This disadvantage is that a signal for a branch line, as given by two steady green lights, may become a signal for the main line if one of the lights goes out, which may consequently give rise to a dangerous situation.

* * *

The original form of the German distant signal (Bavaria excepted) is a circular green disc with a green or white light. In Germany, this type has now been replaced by another, but the old German type has been retained in some countries, for example Finland and Czechoslovakia. In all the countries which have adopted the Central European system of signalling, the disc type is used, but it differs greatly on the various railways as regards form, size, and colour.

In Germany, Bavaria excepted, a round yellow disc, surrounded by a black circle and a white border is used (fig. 7 *a-b*). This signal gives the following indications:

— *the home signal at « danger »* during the day, the face of the disc, at night two yellow lights, placed obliquely above the other, rising from left to right (fig. 7 *a*).

— *home signal clear :* in the daytime the disc horizontal at night, two green lights placed obliquely are above the other, rising from left to right (fig. 7 *b*).

On the Luxemburg railways, the same form is used when the distant signal precedes a one-arm home signal.

On the Norwegian State Railways, nearly the same form is used but without the white border and with all lights flashing (fig. 8 *a-b*).

On the Finnish State Railways, and on most of the Swedish railways, a round green disc (fig. 9 *a-b*) is used, which, in the position, « home signal at danger », « shows towards the train: in the daytime, the face of the disc, at night a green flashing-light, and in the position « home signal at line clear »: in the daytime, the edge of the disc, at night a while flashing-light.

As has already been stated, the old German type is used on the Czechoslovakian State Railways: a round disc with two lights, white and green (fig. 10, *a* and *c*). In addition on these railways a rectangular green signal with a white border (fig. 10 *b* and *c*) is used with the same signification.

This rectangular type is used on the Yugloslavian railways.

On the Swiss Federal Railways, a round green disc, with a diagonal white band (fig. 11 *a-b*) is used as distant signal, which, in the position « home signal at danger », shows towards the train : in the daytime, the face of the disc, at night two green lights side by side, and in the position « home signal at line clear », in the daytime the edge of the disc, and at night two white lights side by side.

All the above-mentioned types of signals can only give two indications for the home signal : danger or line clear. On some railways, however, it has been considered desirable to give, by means of

the distant signals, the indications: line clear for the main line, and line clear for the branch line. This has been carried out on the Guillaume-Luxemburg line, and on some lines of the Swedish State Railways.

On the Guilaume-Luxemburg Railway a round yellow disc is used, surrounded by a black circle and a white border and provided with a small auxiliary arm of yellow colour (fig. 12 *a-c*) (the German type supplied with an auxiliary arm). The signal is used when it precedes a two-arm home signal and serves to give the following indications :

— *home signal at « danger »* during the day, the face of the disc, at night, two yellow lights placed obliquely, rising from left to right (fig. 12 *a*);

— *home signal at « line clear » for main line:* during the day, the disc is turned edgeways, and the auxiliary arm is placed vertically out of sight behind the post, at night, two green lights placed obliquely, rising from left to right (fig. 12*b*);

— *home signal at « line clear » for a branch line (trains must slow down)*: during the day, the disc is placed edgeways, and the auxiliary arm is inclined at an angle of 45° to the right, at night, a green light and a yellow light placed obliquely one above the other, rising from left to right (fig. 12*c*).

On the Swedish State Railways, a similar form is used (fig. 13 *a-c*). As regards the day signals, indications similar to those described for the Guillaume-Luxemburg Railway are given, but for the night signals, a green flashing-light is used for « home signal at danger », and for « home signal at line clear », one and two flashing white lights are used respectively for main line clear and branch line clear.

On all the above-mentioned railways where distant signals in the form of a disc are used, there exists one drawback; in the position « disc edgewise » the visibility of the signal is rather small. Usually, it has been found necessary to mark the position of the signal by a screen placed immediately in front of it, so as to prevent the driver running past without noticing it. In figures 14-16 some examples are given of screens indicating to the driver that he should look out for the distant signal. The screens are only lit up at night by the locomotive headlights.

Figure 14 represents the Swiss form. The screen has a black border, and is crossed by two diagonal black bands.

In Yugoslavia, practically the same form is used, but the border and bands are green.

Figure 15 represents the form used on the railways of Germany and Luxemburg.

Figure 16 represents the Norwegian form.

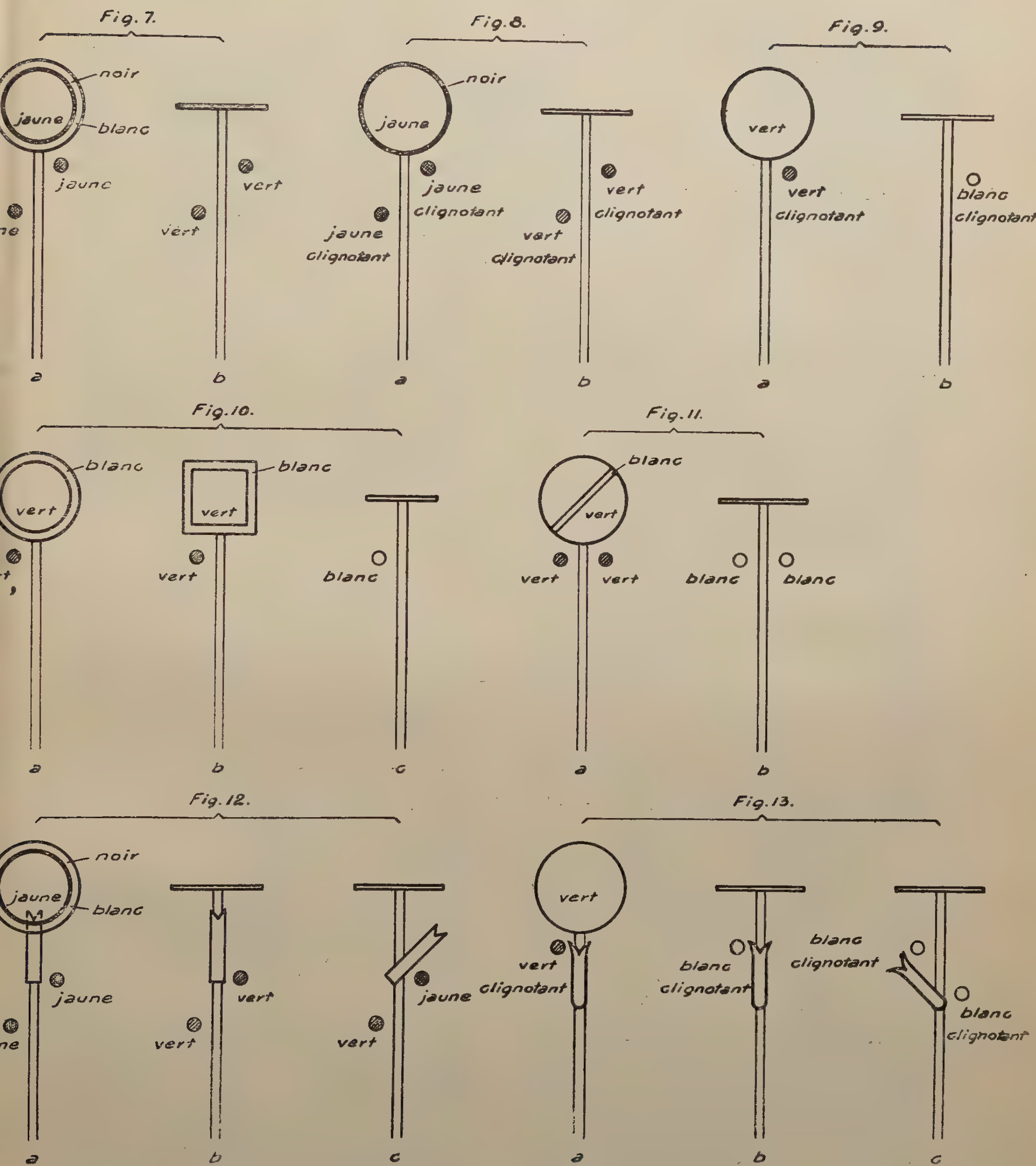
In Bavaria, the signalling disc as used in Central Europe has been modified so as to avoid giving the signal « line clear » by a negation. The Bavarian distant signal is used to give the following indications (fig. 17) :

— *home signal at « danger »* : during the day, the face of the disc, at night, two yellow lights placed obliquely one above the other, rising from left to right (the German form without any alteration);

— *home signal at « line clear »:* during the day, an arm raised obliquely to the right, at night, two green lights.

This result is obtained by bending the disc along two oblique lines.

Even when the home signals, preceded by distant signals, are used in front of a station, it may be difficult for the driver, especially in bad weather, to locate his




Figs. 7 to 13. — Distant signals (system of Central Europe).

*Explanation of French terms* : Blanc = White. — Clignotant = Flashing. — Jaune = Yellow. — Noir = Black. — Vert = Green.

position soon enough if he is running at top speed. For some years, efforts have been made to find means for avoiding this drawback.

The method used, for instance, on the fast traffic line between Brussels and Antwerp which consists in repeating the distant signals in foggy weather by daylight signals, is not employed on the above-mentioned railways.

The use of detonators has been adopted in Luxemburg, where in the near future they will be used at home signals. On some other railways, they are used to inform the driver that he is approaching a home signal at « danger », but as a general rule, they are only used in case of bad weather. This method is employed, for instance, in Finland and in Czechoslovakia where the use of detonators is prescribed wherever the home signal at « danger » is not visible at 200 m. (656 feet). In this case, detonators are placed at least 200 m. in front of the signal at « danger », two of which at least being placed 15 to 20 m. (49 to 66 feet) apart on the right-hand rail, in the direction in which the train is running.

Detonators are used in certain cases in Switzerland and Yugoslavia. In Norway and Sweden detonators are not used in front of home signals.

On the Luxemburg and German railways, a means of indicating to the driver his position has been devised by placing signal boards or signs (balises) along the line.

In Luxemburg, rectangular sign-boards are used, painted in alternate white and red bands, and placed at distances of 30 m. (98 1/2 feet) apart (fig. 18), but these sign-boards are only employed when the prescribed visibility cannot be obtained.

On the German railways, sign boards of a similar form have recently been introduced, but with black bands (fig. 19). The first sign board, with one oblique band, is placed at a distance of 100 m. (328 feet) from the distant signal. The second and third sign-boards are placed, respectively, at distances of 175 and 250 m. (574 to 820 feet).

In Luxemburg, the introduction of repetition of the distant signals in the locomotive cab has been considered. In Germany these installations are becoming general. In Switzerland, this method has not yet passed the preliminary trial stage, trials have taken place employing electromagnetic induction, and it is intended to install on the locomotives, not only optical and acoustical repeaters, but consideration has been given to the adoption of a device for controlling the train automatically.

### 2. *The English system.*

Among the railways dealt with in this report, this type of signalling (in accordance with the « British Ministry of Transport Regulations ») is only employed on the Egyptian Railways.

Figures 20 *a-b* represent the home signal. The simplest form is a post with a rectangular arm on the left.

The semaphores are used to give the following indications :

— *home signal at danger :* during the day, the arm, on the left of the post as seen from the train, is horizontal, at night a red light on the same side as the train (fig. 20).

— *home signal clear :* during the day the arm, on the right of the post as seen from the train, is dropped, at night a green light (fig. 20 *b*).

In front of stations having more than one line, the signal posts are provided with several arms, one above the other

Fig 14.

Fig 15.

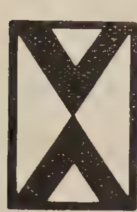
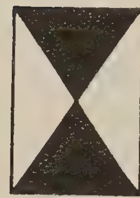


Fig. 16.



Figs. 14 to 16. — Screens placed in front of distant signals.

Fig 17.

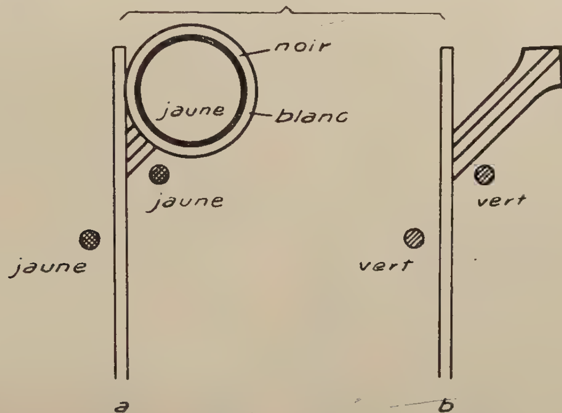



Fig. 17. — Distant signals (Bavarian system).

Fig. 18.

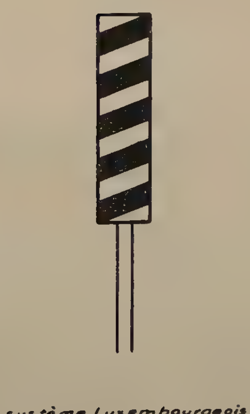



Fig. 19.

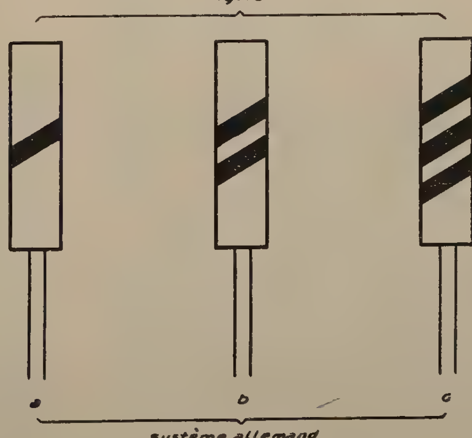



Fig. 18. — Luxemburg system. Fig. 19. — German system.

Figs. 18 and 19. — Warning boards placed in front of distant signals.

(fig. 20 *c*). The number of arms corresponds to the number of arrival lines, the topmost arm corresponding to the first line on the left, and so on.

Semaphores of another form are also used, placed on a bracket or on a gantry. The number of posts always corresponds to the number of roads, and the posts are placed in the same order as the roads. The arms are placed at different heights, so that the highest signal is for the main line (fig. 21).

The home signal arms for secondary lines — goods roads, locomotive roads, etc. are often marked in a special way — goods roads with a circle, locomotive roads with an L.

A train is not allowed to pass a home signal in the danger position without special permission. This permission may be given by a calling-on signal (fig. 22 *a-b*). The calling-on arm is placed horizontally under the main arm of the home signal. When this arm points downwards, or at night a green light is shown, the signal may be run past, and the train may go on as long as the line is clear, but the next danger signal must not be passed. Permission to pass a home signal must not be given by means of the calling-on arm until the train has stopped at the signal.

The home signals are always preceded by a distant signal showing the condition of the home signal. Usually, the signal is located on the same side of the track as that prescribed for the home signal.

The distant signal (fig. 23 *a-c*) consists of a post provided with a rectangular arm ending in a fish tail on the left of the post. The signal serves to give the following indications :

— *home signal at « danger » :* during the day, the arm is horizontal, at night, a red light.

— *home signal at « clear » :* during the day, the arm is lowered, at night, a green light.

Very often the distant signal is combined with a main signal, for instance, by placing, below the home signal, the arm of the distant signal preceding the following starting signal (fig. 23 *c*).

As has already been mentioned, the form of the arm serves to distinguish between the main signals and the distant signals, but no such distinction exists for the night signals. Consequently, a driver on coming to a signal, has to decide, whether the red light belongs to a distant signal, in which case he may pass it, or to a main signal, in which case he must stop, and he cannot pass the signal at danger without special permission.

In addition, very detailed rules control the arrival of a train, when the following section is not free, and when the station is not provided with starting signals, but these rules being practically the same as those at present in force in England, it has not been considered necessary to give the details in this Report.

### 3. *Intermediate systems.*

The systems of signalling used in Holland and Denmark constitute systems, which from the point of view of principle, occupy a position intermediate between the systems used in Central Europe, and the English system, which has just been described.

In Holland, in front of stations having only one arrival line, a signal post is used with one rectangular arm, terminating in a sector of a circle, and with a lamp at night (fig. 24).

The semaphore is used to give the following indications :

— *home signal at danger :* during the day, the arm, as seen from the trains,

Fig. 20.

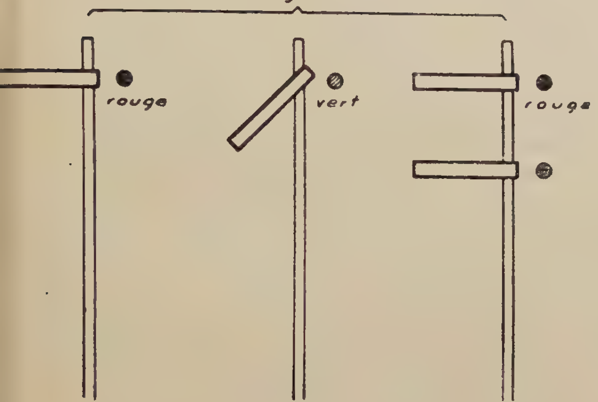



Fig. 21.

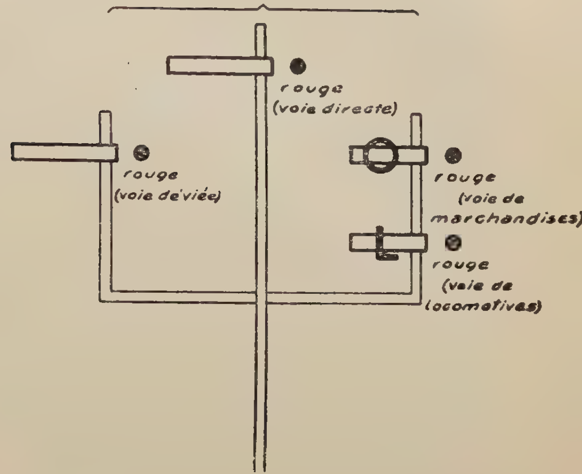



Fig. 22.

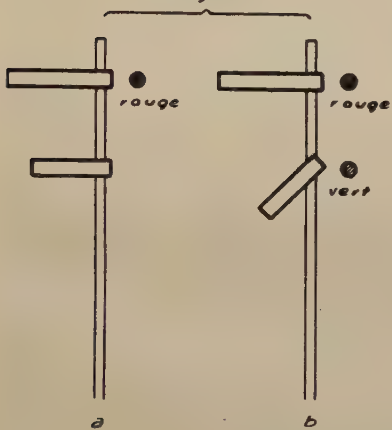
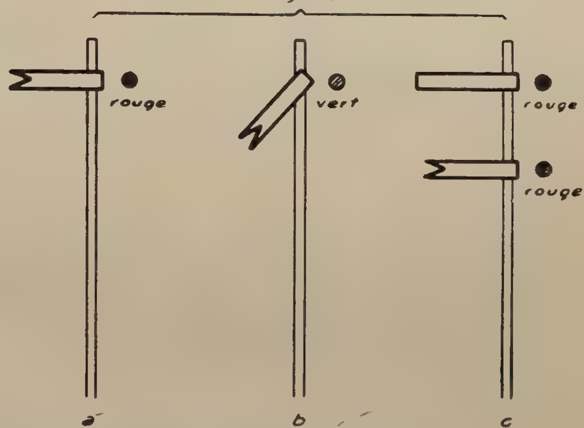



Fig. 23.




Figs. 20 to 23. — Home signals and distant signal (English system).

*Explanation of French terms* : Rouge (voie déviée) = Red (branch line). — Rouge (voie directe) = Red (main line). Rouge (voie de marchandises) = Red (goods line). -- Rouge (voie de locomotives) = Red (locomotive line).

pointing to the right of the post, is horizontal, at night, a red light on the same side as the train.

— *home signal clear :* during the day, the arm, as seen from the train, pointing to the right of the post, is lifted upwards at an angle of 45°, at night, a white light on the same side of the train.

In front of stations having more than one arrival line, semaphores of another from are used, placed on a bracket or on a gantry. The number of posts always

corresponds to the number of arrival tracks and the posts are placed in the same order as the tracks. Each post is provided with a fish-tailed arm (fig. 25). If the posts mounted on a bracket or gantry in front of a station are of varying heights the clear signal given by the shorter post or one of the shorter posts, indicates that the train can run in on a line when the speed should not exceed 45 km. (28 miles) an hour. When other speed limits are to be indicated, the post is provided with a square, white board, bearing the permissible speed in black figures. The positions, the lights, and their meanings are identical with those described above.

The home signals are always preceded by a distant signal, indicating the position of the corresponding home signal. Usually the signal is located on the side of the track prescribed for the home signal.

The distant signal (fig. 26), which precedes the home signal (fig. 24) consists of a post provided with a rectangular arm placed on the right of the post, at night, a light. It gives the following indications :

— *home signal at « danger » :* during the day, the arm is inclined downwards at an angle of 45°, at night, a green light.

— *home signal « clear » :* during the day, the arm is inclined upwards at an angle of 45°, at night, a white light.

The distant signal (fig. 27) which precedes the home signal (fig. 25) consists of a post provided with two rectangular arms at night, two lights. It gives the following indications :

— *home signal at « danger » :* one of the arms is raised vertically, the other is inclined downwards at an angle of 45°; at night, two green lights next to each other.

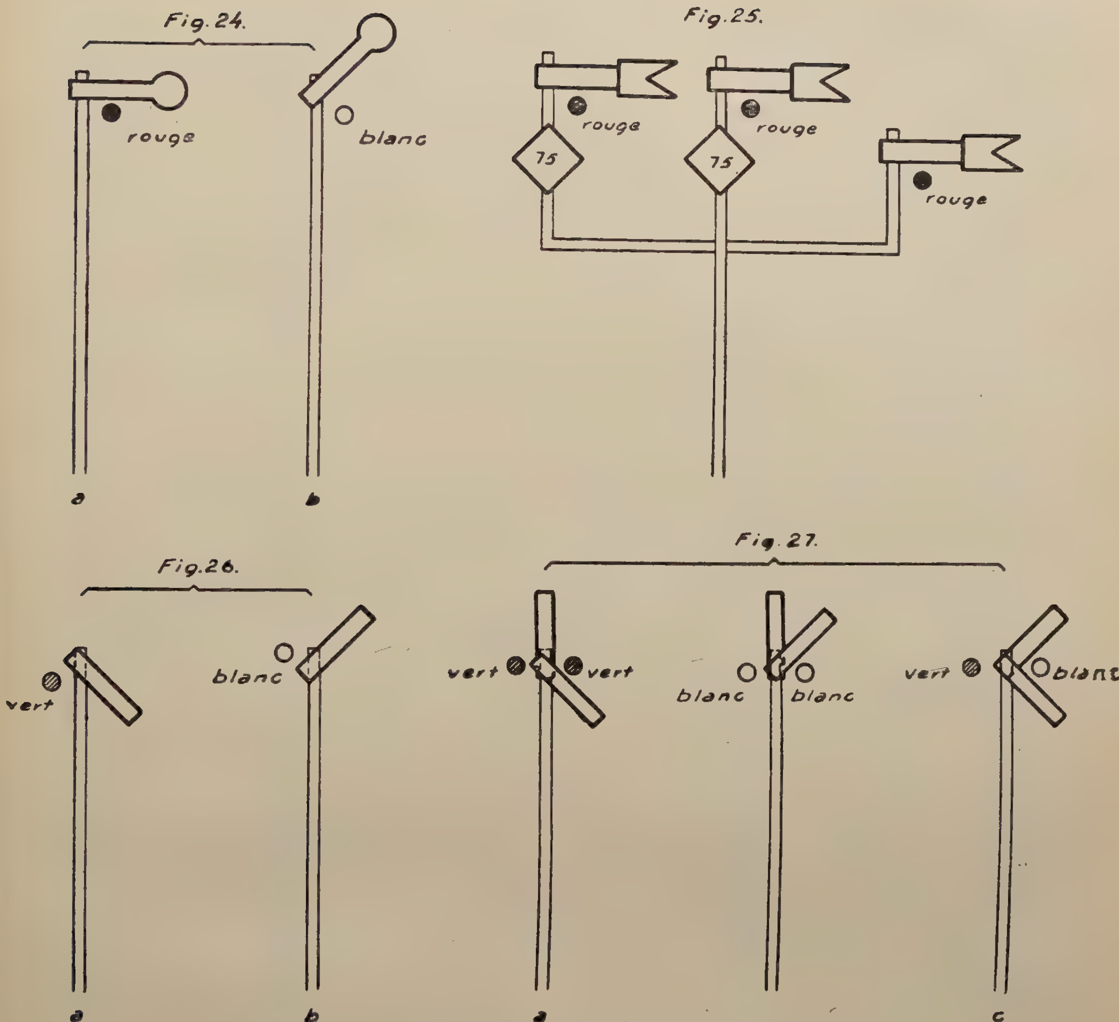
— *home signal « clear » for a track on which the permissible speed exceeds 45 km. (28 miles) :* during the day, one of the arms is raised vertically, the other is raised obliquely at an angle of 45°; at night, two white lights next to each other.

— *home signal at « clear » for one of the tracks on which the speed must not exceed 45 km. (28 miles) :* during the day, one of the arms is raised upwards to an angle of 45° and the other is lowered to an angle of 45°; at night, a green light and a white light next to each other, the white light being on the right.

On the Danish lines for fast traffic, where trains may run through a station without stopping, the stations are protected by double-arm home signals. These arms are not used to give the same indication as in Central Europe. In Denmark, the home signals do not give « through line » and « branch line », but a distinction is drawn between line clear for a train which must stop in a station, and for a train which has not to stop. The signal is shown in figure 28. The semaphore consists of a double-arm with, a night, two lights. The upper arm (main arm) is rectangular in shape, and ends in the sector of a circle, and the lower arm, placed 1.58 m. (5ft. 2 in.) below the upper arm (arm for through trains), which may be regarded as the distant signal of an existing or non- existing starting signal, is rectangular and fish-tailed. The signal serves to give the following indications :

— *home signal at danger :* during the day, the two arms, seen from the train on the right of the post, are horizontal; at night a red light above a yellow light;

— *line clear for a train which has to stop at the station :* the upper arm, seen from the train on the right of the post, is raised obliquely at an angle of 45°, the




Figs. 24 to 27. — Home signals and distant signals (Dutch system).

lower arm is horizontal; at night a green light above a yellow light;

— *the train may run through the station without stopping* : during the day, the two arms raised obliquely; at night two green lights one above the other.

In front of stations where trains always stop — obligatory in front of a terminus — the signal described above is often used without the lower arm and the lower light (fig. 29). The home signals are preceded by distant signals, indicating condition of the corresponding home signal. The distant signal is placed on the right of the track. It consists of a post provided with a rectangular fish-tailed

arm, capable of turning about a horizontal axis; at night, a flashing- light. The signal is used to give the following indications (fig. 30):

— *home signal at* « *danger* » *:* during the day, the arm is horizontal; at night a yellow flashing-light;

— *home signal* « *clear* » *:* the arm is raised upwards to an angle of 45°; at night a green flashing-light.

As has already been mentioned above, the distant signals in Holland and Denmark are placed at a fixed distance 700 (500) and 400 m. [2 297 (1 640) and 1 312 feet], respectively, from the home signal. It has been thought necessary in these two countries to provide the driver with means for finding his position. Since the adoption of permanent sign boards, detonators are only used in front of home signals in cases of exceptional danger. The signs are placed at fixed distances in front of the home signals. They are not illuminated at night, but they are always placed as close as possible to the track so that they may be sufficiently illuminated by the locomotive headlights. In Holland, where these signs are used in front of stations, junctions, and block signals, two signs are used in front of a main signal. The signs consist of two boards 5 m. (16 ft. 5 in.) long, slightly inclined towards the track, 12 m. (39 1/2 feet) apart, and rising in the direction in which the train is running (fig. 31). They are painted in white, with black sloping bands, and are placed on the right of the track about 850 m. (2 789 feet) in front of the home signal.

When it is necessary to place the signs at a distance which is not normal, the actual distance is marked very distinctly on the signs.

In Denmark, signs have been erected in front of stations and junctions on all the lines. These signs are placed at a fixed distance in front of the home signal, on the right hand side of the track in such a way that the first sign, having three sloping rectangular boards, one above the other (fig. 32) is at a distance of 600 m. (1 968 feet), the second, with two boards, at 800 m. (2 624 feet), the third, single board, at 1 000 metres (3 280 feet).

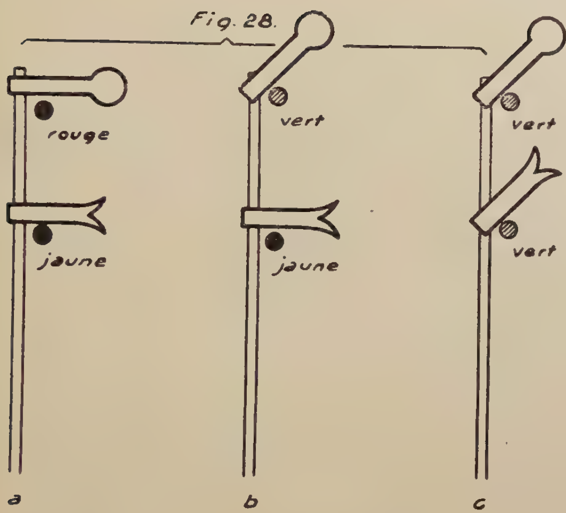
The boards are painted white and surrounded by a red border.

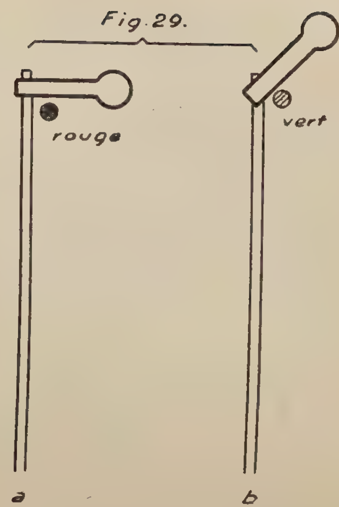
In Holland and Denmark, repetition of the signals in the locomotive cab is not used.

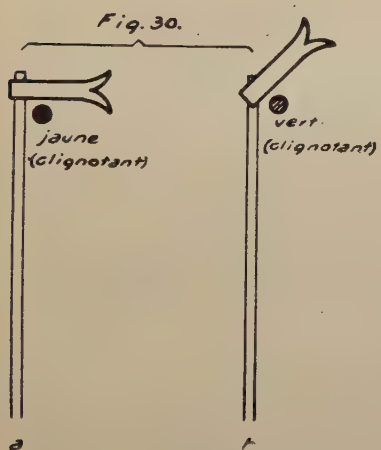
* * *

As follows from the descriptions given above, the home signal has been construted on the various railways in accordance with two different principles. In the countries where the Central European system has been adopted, it has been considered necessary to concentrate attention on the fact that it is useful to inform the driver whether he may run in on a through line or a branch line. As it became necessary to warn the driver of the condition of the starting signal before he entered the station, the starting signals were repeated by distant signals, often mounted below the home signals.

On the other railways, Egypt, Holland, and Denmark, the home signal has been constructed in such a way as to be able to indicate whether the train entering the station must stop, or whether it may run through. By placing the arms at different heights, providing them with special signs, and placing on the home signal posts discs showing the permissible speed, an endeavour has been made to give the driver the same information as that given by the system of signalling employed in Central Europe, which indicates arrival on the through line, and on the branch line.




Figs. 28 to 30. — Home signals and distant signals (Danish system).

Up to the present, separate indication for the through line and for the branch line has been abandoned in Denmark, point signals being considered sufficient. A commission appointed to study signalling recently proposed to increase the size of the point signal corresponding to the point by which the first deviation is made, and if necessary, to repeat this signal at the foot of the home signal.

B. — **Starting signals.**

For starting signals, the rules are more varied than those for home signals. On most railways, a main signal, of the same form as the home signal, is used. As a

Fig. 31.

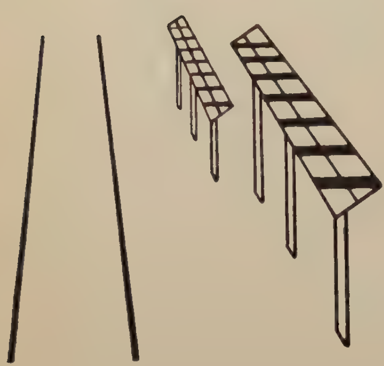
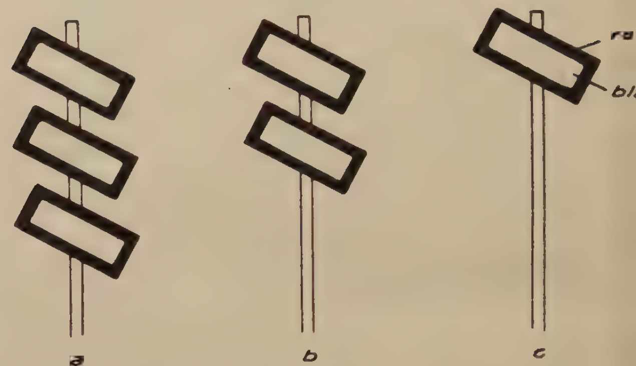


Fig. 32.




Figs. 31 and 32. — Warning boards (Dutch and Danish).

general rule, the signal is located on the right (left) of a train leaving the station, if the home signal is placed on the right (left). On starting semaphores, the arms are placed on the same side of the post as the home signal arms.

1. *The systems of Central Europe.*

As a typical example of the signalling system employed in Central Europe, the system used in Germany (Bavaria excepted) may be taken.

The form of the starting signals is identical with that of the home signal described above. If the station has two departure lines, each starting signal is placed on the right of the corresponding track. The starting signal has as many arms and, at night, lights as there are possible routes out of the station.

The signals serve to give the following indications :

— *starting signal at danger* : during the day, the arm (upper arm) seen from the train to the right of the post is horizontal; at night, a red light on the same side of the train;

— *signal clear for through road* : during the day, the arm (upper arm) seen from the train to the right of the post, is raised upwards at an angle of 45°; at night, a green light on the same side of the train. If the signal has more than one arm, the other arm is placed vertically out of sight;

— *signal clear for branch line* : during the day, the two arms seen from the train are raised upwards at an angle of 45°; at night, two green lights on the same side of the train.

The Guillaume-Luxemburg Railways employ the same starting signal system as Germany (Bavaria excepted).

The Czechoslovakian State Railways employ for each departure track a signal of the same form as the home signal (fig. 6). The signals are located in accordance with rules similar to those applying in Germany, and the signals have the same meaning in both these countries.

The Finnish State Railways also use one starting signal for each departure road, usually with one arm and of the same shape as the home signal.

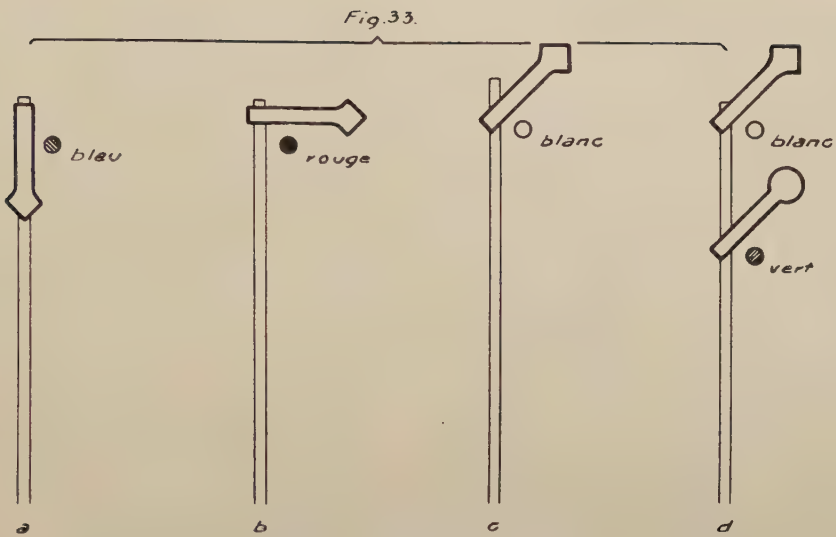



Fig. 33. — Starting signals (Bavaria).

On the Swedish State Railways, a signal may be placed at the side of each departure track or a common starting signal beyond the last point. There are also stations where starting signals have been placed at the side of each departure road *and* a common starting signal beyond the last point. The signals have the same form and the same lights as the home signals (fig. 5). Flashing- lights are often used for the « danger » signal.

In Norway the starting signal has also the same form as the home signal, that is to say, permission for departure on the through line is given by two raised arms, and for the branch line by one raised arm.

In Switzerland, the same form is used for the starting signals as for the home signals, but with a different meaning from that in Germany. Each departure track may be provided with a starting signal (track signal), in which case it is admissible to use a common post for several track signals (semaphores with several arms). When several lines leave a station, each line must have its own starting signal (line signal), placed on a special post, even when there are already road signals.

Consequently, the various arms of a starting signal do not indicate the line for which departure has been prepared, but the track by which the departure is being made.

On the Yugoslavian Railways, starting signals of the same form as the home signals are employed.

The starting signals on the Bavarian Railways are of quite special form (fig. 33): when the home signal is at « danger », all the arms of the starting signals for the corresponding direction are placed vertically out of sight (fig. 33*a*). When the home signal is at « clear » for a train which has to stop in the station, the starting signals remain in the normal position except the signal of the line to which the home signal gives access. For this line alone, the starting signal is set at « danger » : the

upper arm horizontal, on the right of the post; at night a red light. The indication « line clear » for the departure is given by the upper arm being raised obliquely (at night, a white light), and this indication is the same whether the departure road is a through line or a branch line. Only in the case where the signal « through » is given by the home signal, is the starting signal used to give the indication that not only is the departure line clear but whether it is a through line or a branch line. In the first case, the starting signal shows towards the train an arm raised obliquely (at night, a white light) in the second case two arms raised obliquely (at night a white light above and a green light below). In recent years, this method of signalling has been modified, so that white lights shall no longer be employed in main signals.

As has already been described above, a home signal is usually preceded by a distant signal, with the exception of Finland, where the distant signal is not compulsory. The rules are less definite as regards starting signals. There are railways on which a distant signal is placed in front of a starting signal. Generally, it is not permitted to run through a station except on one line, and consequently the distant signal referred to can give an indication only for this line, this signal is only used when a train has to pass a station without stopping.

On some railways, the distant signal is often combined with the home signal, as for example in Sweden and in Bavaria.

On the Swedish State Railways, the starting signals are often preceded by a distant signal, consisting of a pointed arm placed on the same signal post, a few metres from the ground (fig. 34). The signal is used to give the following indications:

— *Starting signal at « danger »:* during the day, the arm horizontal, to the left, at night, a green light (the arm of the home signal in this case can only assume the positions « danger » or « clear »).

— *Signal clear for through trains :* by day the arm raised obliquely, to the left; at night a white light (in this case the arm of the home signal can only assume the position « through-road clear »).

On the contrary, if the train has stopped in the station, only the main signal clears while the distant signal remains at danger.

On the Bavarian Railways the distant signal has also been placed on the home signal post (fig. 35). The ordinary type of the distant signal placed in front of home signals is used, and the signal serves to give the same indications. The old Bavarian form has only been modified as regards the night signals, by adopting the standard German form : two green lights or two yellow lights.

On the Norwegian State Railways, the distant signal placed in front of starting signals, is located at the side of the home signal, or between the home signal and the first points. This signal is the same type as the distant signal located in front of home signals, and gives similar indications.

On the Swiss Federal Railways, the distant signal located in front of a starting signal is the same type as the distant signal placed in front of the home signal (fig. 11) and it is generally located alongside the home signal. The indications given by this signal differ a little from those given by the distant signal located in front of the home signal:

— *through line clear* is indicated in the ordinary way by turning the disc edgeways on, and at night by two white lights alongside each other.

Fig. 34.

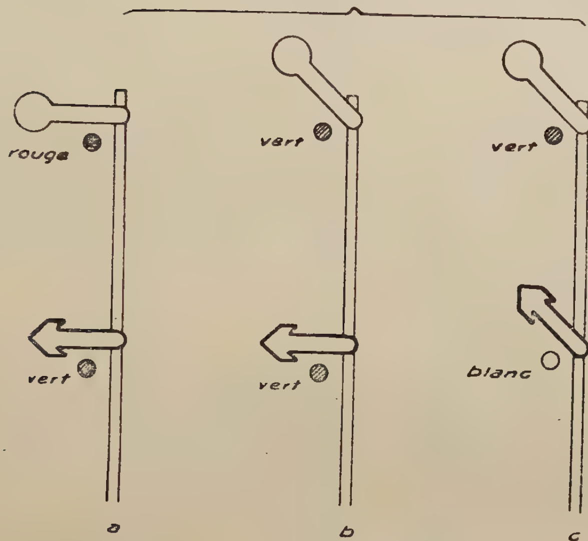
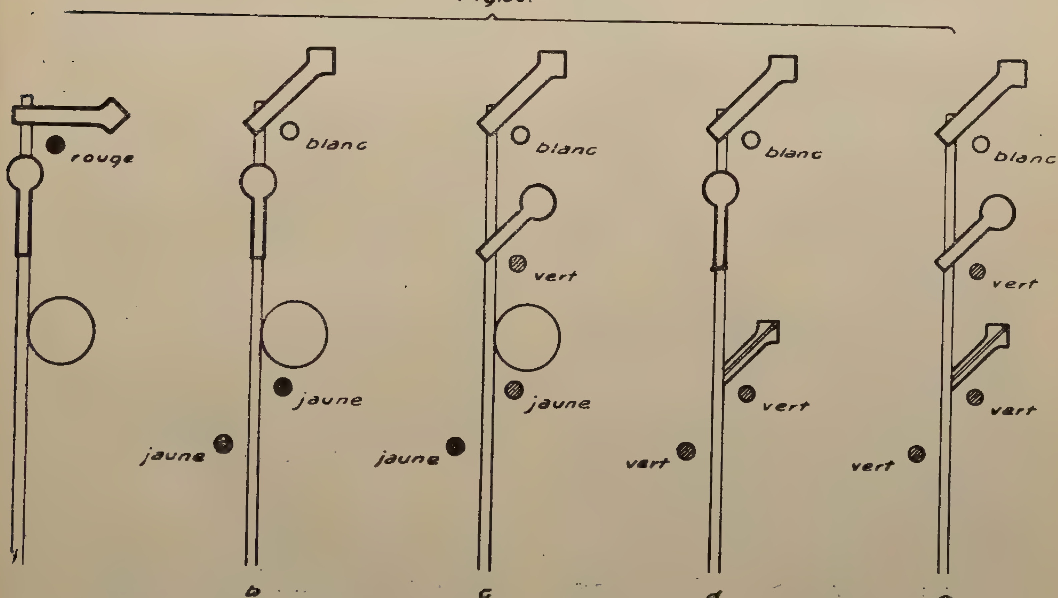



Fig. 35.




Figs. 34 and 35. — Distant signals placed before starting signals (Sweden and Bavaria).

— *through line closed, a branch line clear* is indicated by the face of the disc; at night two green lights alongside each other.

2. *The English system.*

On the Egyptian Railways, the same types of signal are used for the starting signals as those used for the home signals. This rule applies to both day signals and night signals. A starting signal is placed immediately to the left of the track to which it applies, and gives the following indications :

— *danger:* during the day, the arm, as seen from the train, on the left of the post, is horizontal; at night, a red light on the same side of the train;

— *line clear:* during the day, the arm is inclined downwards; at night a green light.

When considered necessary, the starting signal may be repeated by an advance starting signal which has the same form, and which gives the same indications as the starting signal.

When the starting signal is placed at such a small distance that it is necessary, for a train stopping at the station, to pass it, without however passing the advance starting signal, the indication « line clear » is only given when the train has stopped in front of the starting signal at « danger ».

The advance starting signal, or if there is none, the starting signal, controls the arrival of a train in the following section. Generally the signals, when at danger, must not be passed without special permission. These rules also apply to shunting in stations. The necessary permission may be given by a shunting arm placed on the home signal, and the arm inclined downwards indicates that the main signal on which it is placed may be passed, even though this may be at danger. These signals have no meaning for trains, but, when a train has to pass such a signal, there are detailed regulations, similar to those applicable for the passage of a home signal at danger. The distant signals which precede the starting signal are as a general rule fixed to the posts of the preceding main signals. These signals may be passed when they are in the « danger » position.

* * *

In England, where the signalling system employed in Egypt was created, there are periods in the winter of thick fogs and often it becomes necessary to warn the driver before he passes the distant signal and to indicate its position to him. In Egypt, as in England, detonators are used in this case, not only in time of fog but also during sandstorms, a trouble which often arises on the Egyptian lines.

In accordance with the regulations, detonators are placed on the line, when the visibility of the signal is less than five intervals between the telegraph poles.

In this case a fogman is placed in front of each distant signal. He places the detonators on the rails when the signal is at danger and takes them off when it is cleared. The fogman also shows a red or green light to the driver as the case may be.

In Egypt neither warning boards nor drivers' cab signals are employed.

3. *The intermediate systems.*

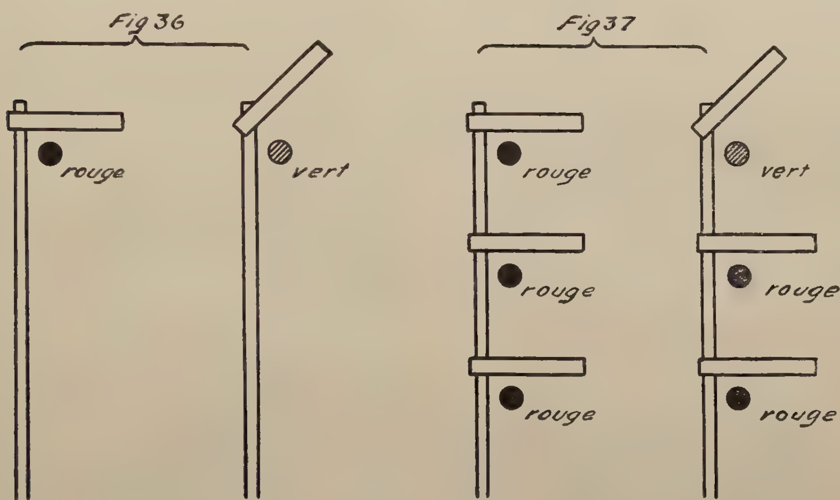
On the Dutch Railways, the same form is used for the starting signals as has been adopted for simple home signals (fig. 24). Single-arm signals are used, and they are placed immediately to the right of the corresponding track. The positions and

the lights are similar to those already described for home signals.

The starting signals for a line by which the station may be passed without stopping, are always preceded by a distant signal, which may be placed on the post of the preceding main signal, in which case it is placed under the principal arm commanding the corresponding line.

On the Danish State Railways, the starting signals are sometimes discarded, it being understood that it is possible to inform the driver by means of the home signal whether he is allowed to pass the station without stopping, or whether he ought to stop.

As regards stations provided with starting signals, such a signal is usually placed immediately on the right of the track which it commands, or if that is impossible, they are placed side by side in the same order as the corresponding tracks.




Figs. 36 and 37.

Signals with rectangular arms are always used (fig. 36) which serve to give the following indications:

— *Danger:* during the day, the arm is horizontal, at night, a red light;

— *Clear:* during the day, the arm is raised obliquely; at night, a green light.

Formerly, a common signal for all the tracks of departure was employed (fig. 37). The upper arm of such a signal referred to the track which was on the extreme left, the next arm to the next line, and so on. When several lines left one station, each line had its own signal with a number of arms corresponding to the number of roads by which it was possible to leave the station by this line.

At the present time, when several lines leave one station, a route signal is employed for each of them. These singals have the same form and serve to give the same indications as those described above. When this system is used, each train has to be given two signals; a starting signal and a route signal. If departure by one road leads to more than one line, the

route set is often indicated on the post of the route signal by means of a letter.

This method of signalling the departure from a station has given rise to the following disadvantage: the signals of the departure track being usually placed inside the station, it is often necessary for an arriving train to run past these signals, even if the corresponding signal is at « danger ». In order to avoid this disadvantage, the above-mentioned Commission, which has been appointed to study questions of signalling, proposes changing the signals, so as to distinguish between starting signals and route signals by using different shapes of arms on the two signals, and also different lights for the danger positions. The proposal has been made to replace the red and green lights by yellow and green lights as regards the starting signals, and to retain the lights actually in use for the route signals.

* * *

The systems of signalling described above, as employed on five different railways, are shown in figures 38 to 42. The system of signalling employed in Central Europe is shown in figures 38 and 39, which refer to the State Railways of Czechoslovakia and Norway. The English system, as used on the Egyptian Railways is shown in figure 40, and the intermediate systems, as regards the Dutch and Danish railways, are shown in figures 41 and 42. All the figures give both the danger signal and the signal for non-stop trains.

### C. — Signalling for a turn-out.

In most of the above-mentioned countries, a turn-out is protected by signals of the same form as those employed in stations. As a typical example, figure 43 shows the protection for a turn-out as employed in Germany. The position of the signals is identical with that of the signals protecting a station. For facing points double-armed signals are used, so as to show whether the train should pass by way of the through line or run on to the branch lines. For trailing points, a one-arm signal is employed, even if the trains is on the branch line.

A similar system is employed in all countries which have adopted the system of signalling of Central Europe, with the exception of Finland where, when approaching facing points, the turn-out is protected by as many signals as there are branch lines.

On the railways of Egypt and Holland, turn-outs are protected in the same way as a station, that is to say, when approaching facing points, there are as many signals as there are branch lines, while when approaching trailing points, only one one-arm signal is employed for each line.

In Denmark, when a station having more than one arrival track is only protected by one home signal, the principle described above in connexion with the railways of Egypt and Holland is employed for protecting the turn-outs, that is to say, for trains approaching the facing point, there are as many signals as there are diverging lines (see fig. 44).

On all the railways, the signals protecting a turn-out are always preceded by distant signals placed in the usual way.

### D. — Block signals.

On all the railways in question, the ordinary one-arm home signals are employed as block signals, with the exception of Denmark, where the arm of the block signal ends in a diamond.

On some single-line railways, the arms

Fig. 38.

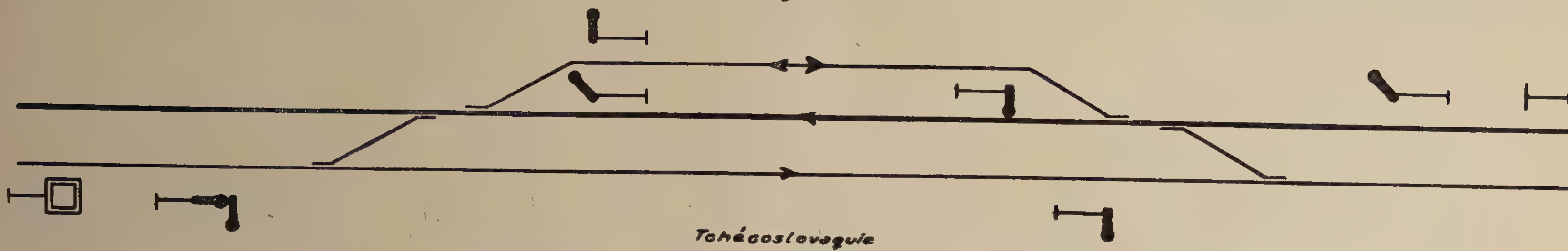
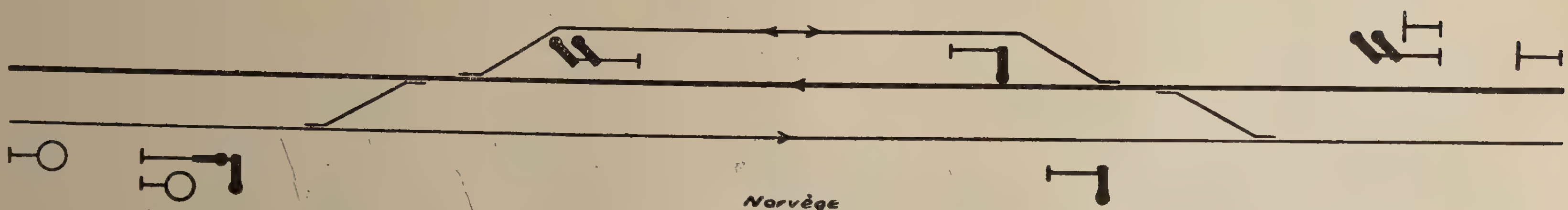



Fig. 39.




Figs. 38 and 39. — (Fig. 38 : Czechoslovakia. — Fig. 39 : Norway.)

Fig. 40.

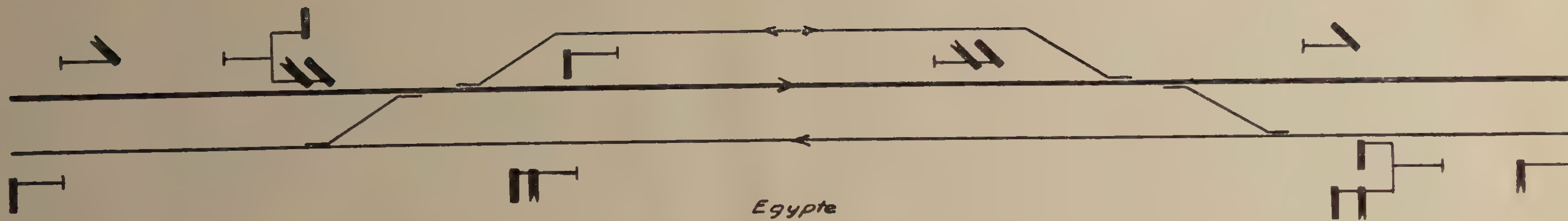



Fig. 41.

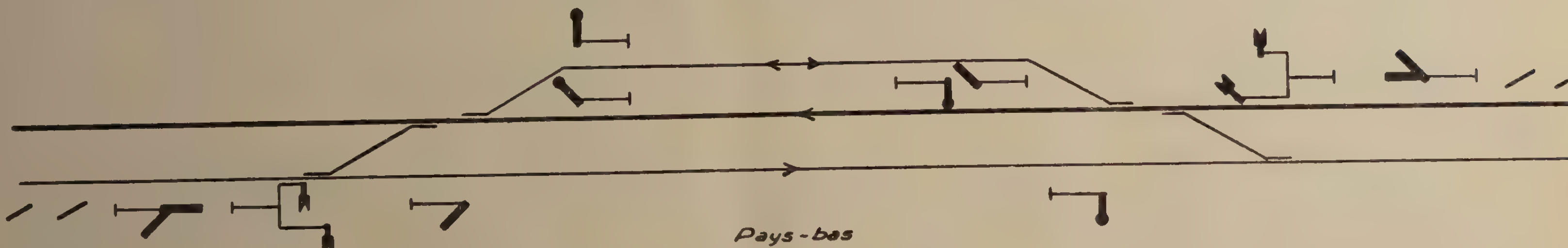
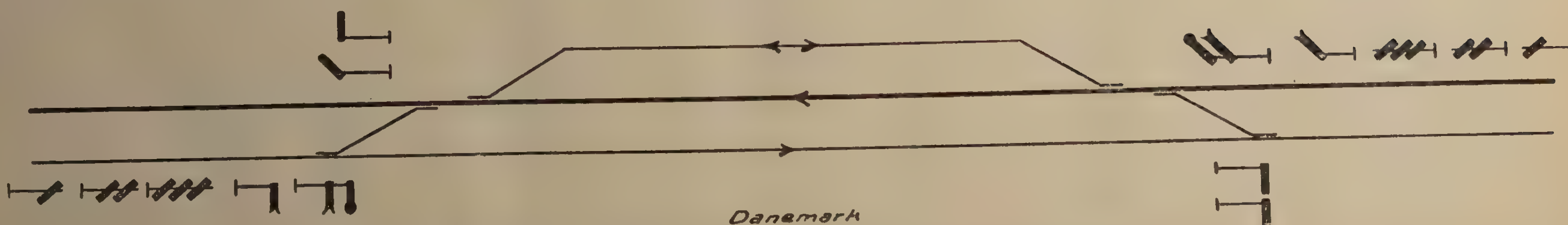
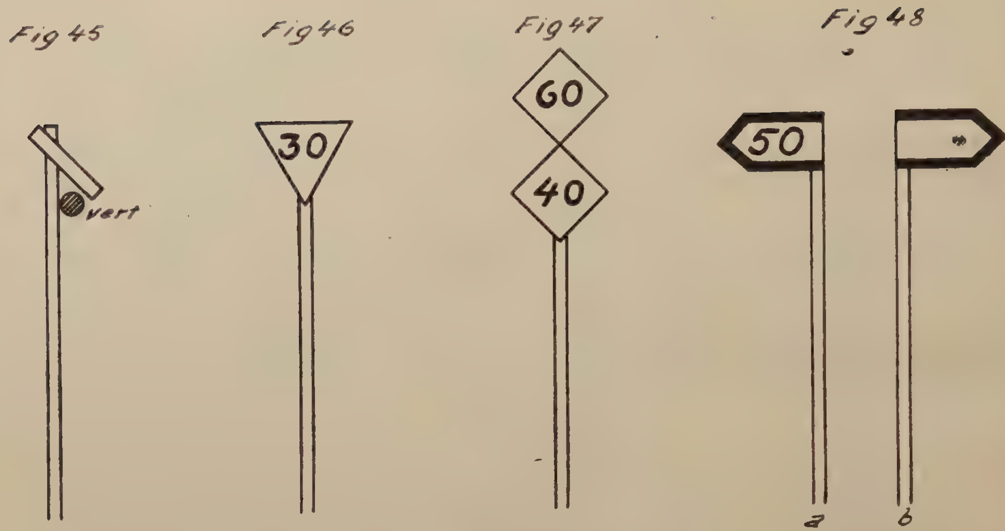



Fig. 42.




Figs. 40 to 42. — (Fig. 40 : Egypt. — Fig. 41 : Holland. — Fig. 42 : Denmark.)


Figs. 43 and 44. - (Fig. 43 : Germany. — Fig. 44 : Denmark).




Figs. 45 to 48.

for traffic in either direction are placed on the same post; this is the case in Finland and Denmark.

In Denmark, warning boards are not placed in front of the block signals.

E. — **Signals for speed reduction.**

On several railways, special signals or boards have been introduced to indicate to the driver a fixed statutory reduction of speed. In Czechoslovakia, a signal (fig. 45) is used, which consists of a post with an arm inclined downwards at an angle of 45°, to the right; at night, a green light on the same side of the train. This signal is placed 45 m. (148 feet) in front of the spot where the speed of the train has to be reduced, and it should be visible for at least 200 m. (656 feet).

On the Yugoslavian Railways, the same form of signal is used to indicate a reduction in speed. On the German State Railways, a triangular plate is used bearing the permitted speed in black figures (fig. 46).

On the Luxemburg railways, diamond-shaped signals (fig. 47) are used, bearing the authorised speed in black figures on a white background. The top diamond refers to passenger trains, and the lower diamond to goods trains, while a single diamond refers to all trains.

On the Swedish State Railways, a triangular plate is used on which is marked the permitted speed and the length of the corresponding section.

On the Norwegian State Railways, the permitted speed is shown by a plate (fig. 48*a*), placed at a suitable distance in front of the section which the train has to run through at the prescribed speed; the end of the section is marked by another plate (fig. 48*b*).

On the Dutch Railways, a white square is used of the same form as that shown in figure 25, bearing the prescribed speed in black figures.

F. — **Lichting of signals.**

Originally, oil-lamps were used on all the railways, and such lamps are still used

on most railways. The light is usually concentrated by means of a parabolic reflector. Some railways have given perticulars of the type of lamp employed; this is the case for Czechoslovakia, for which the following information has been received:

Approximate power, 16 candles, consumption 0.013 kgr. (0.459 ounce) per hour, width of wick, 17.5 mm.(11/16 in.). The lamps burn for about twelve hours, without re-filling. Each lamp is provided with a parabolic reflector having a parameter of 44 mm. (1 3/4 inch). The reflector is made of polished silver-plated steel. No lenses are used.

In recent years, electric signal lighting has been introduced on many lines. Many different types of lamps are used. In Switzerland, electric lighting has been installed on about 50 % of the main lines, and its use is being extended. The voltage of the lamps varies from 50 to 220 volts, being generally 150 volts. Each lantern is provided with two lamps of 10 to 16 watts, connected in parallel and always lit together. The beam of light has a maximum of 30 Hefner candles.

In Norway, with practically no exceptions, electric lighting is used in all main and distant signals. There is only one lamp of 120 volts and about 25 candle power in each lantern.

In Sweden, electric lighting is used in half the main signals (the others are lit by acetylene). Only one lamp is used in each lantern, and at the moment efforts are being made to standardise it, so as to use 55 volts, 20 watts.

In Finland, electric lighting has been introduced on a small part only of the main signals. 65, 110, and 220 volts, and about 25 watts, are used.

In Czechoslovakia, electric lighting has only been introduced in a few stations by way of trial. The best results have been obtained with 60 volts, 15 watts, and about 12 candle power.

In Holland, electric lighting has also only been introduced on a very small part of the signals; 120 volts and 10 watts are used.

In Luxemburg and Yugoslavia, electric lighting is as yet only used to a very small extent.

* * *

Flashing-lights have been introduced on several railways to give a special character to the various signals. In the section dealing with the description of signals it was pointed out that flashing-lights are used in some cases, and in the following, particulars are given regarding the character of these signals.

In Sweden, the number of periods is 50 to 60 per minute, and for starting signals, 0.1 second.

In Norway, the number of periods is 60 to 80 per minute, and the duration of the flash of light is 0.1 to 0.5 of the total period.

In Denmark, the number of periods is 60 to 70 per minute, and the duration of the flash of light is the same as in Sweden.

In Finland, the number of periods is 60 per minute, and the duration of the flash of light is 0.1 to 0.5 of the total period.

In Holland, the number of periods is 60 per minute, and the flash of light is 0.2 second in duration.

The five countries mentioned above make considerable use of the Aga acetylene system for flashing-light signals. When electric flashing-light signals are installed, the duration of the flash of light is generally greater than that used for acetylene signals.

In Czechoslovakia, tests are being made

with white flashing-light signals of various systems (Siemens-Halske, Kremenetzky, F. L. Krizik). The ratio of lighting to extinction is about 2 to 1.

On the Swiss Federal Railways, trials have been made with flashing-lights in distant signals preceding home signals, both with acetylene and with electric lighting. The number of periods is 60 to 80 per minute; the period of darkness and the period of light have practically the same duration.

By employing flashing-light signals, it has been possible to increase the number of types of night signals which may be used. This means a rather considerable advantage, because there are not many colours which are sufficiently visible.

## CHAPTER IV.

### Signalling in main stations.

In Chapter III a description has been given of the normal signalling for the entering and leaving of an ordinary station. The special feature of main station signalling is the method of signalling the arrival and the route prepared. For all the countries dealt with in this Report, the home signal (or the signal for a turnout) and the distant signal are the same for all stations. When, however, it is impossible to give sufficiently exact information by the home signal for arrival on such and such a track, the home signal is often supplemented by route signals. As a typical example, a description is given below of the system of signalling which has, up to the present, been considerably employed in Germany.

In the main stations, where there are more than three arrival tracks, it is not possible to indicate by the three arms of the home signal for which of the various roads the route is set up; in this case a double-arm signal is often used as the home signal, and is supplemented by single-arm route signals, placed directly on the right of the corresponding tracks (see fig. 49 *a*). Route signals provided with more than one arm have also been used, so that each signal protects the branching of two or three tracks (fig. 49 *b*). The route signals are like the home signals, both during the day and at night. At the present time, efforts are being made to avoid the overcrowding of signals which often results from the use of route signals, it being considered necessary to avoid the trains passing more than one main signal on arrival. In this case the indications which are given are restricted to the two which can be given by the home signal, namely, line clear for the through line, and line clear for the branch line.

In many of the other countries dealt with in this Report, the same evolution has made itself felt. In Sweden, the general opinion is that it is not necessary to signal the arrival track, but the fact must be taken into consideration that the introduction of dwarf signals — see below — provides the driver with very exact information regarding the arrival track and enables the use of special signals for the arrival track to be dispended with.

In Norway, the route prepared is often indicated by a special signal (fig. 50). This signal shows on a white plate, the number of the track in black figures, visible both from the train and from the station at the same time. The signal is placed 50 to 100 m. (164 to 328 feet) in front of the first points. Information is often given by luminous signals, in which case the number of the track is indicated by a luminous figure on a black background.

A corresponding signal is used for all departure tracks, and the figure, in this case, indicates the route for departure.

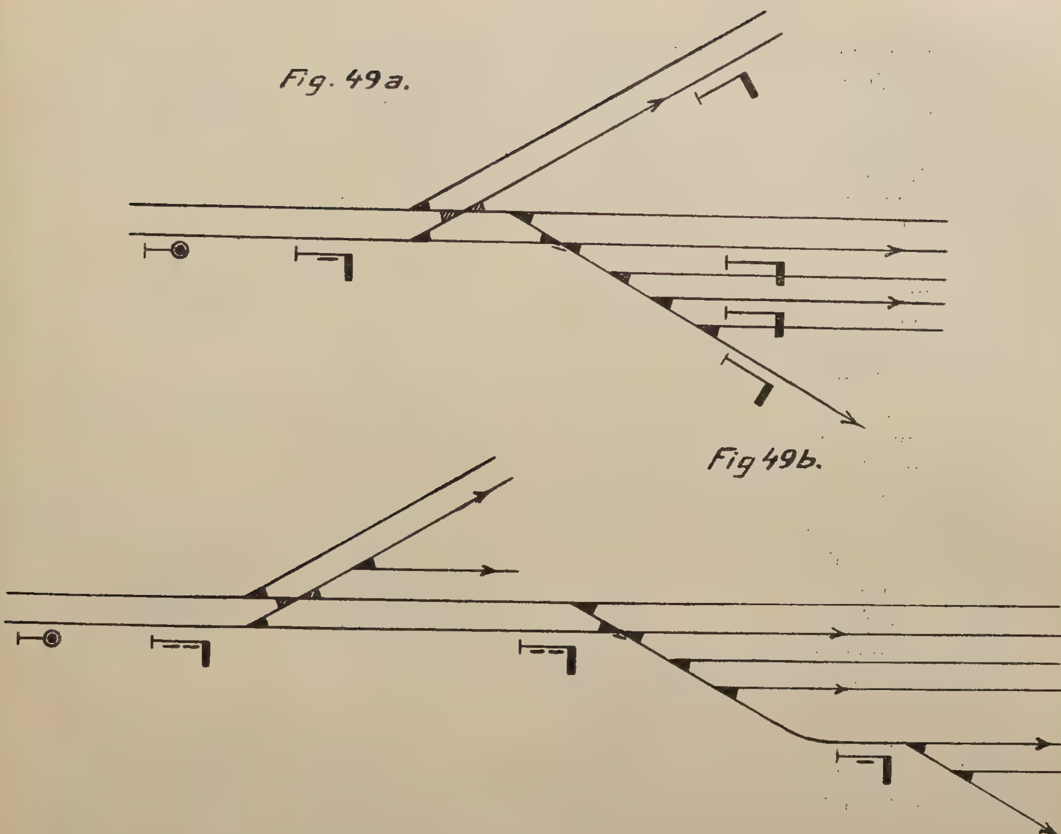



Fig. 49.

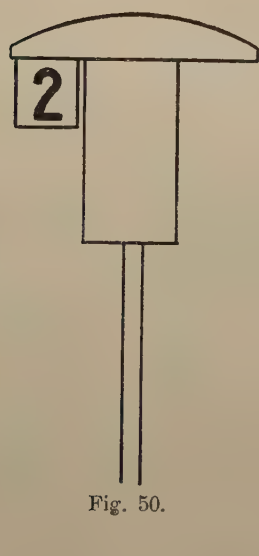



Fig. 50.

In addition, the line for which the track is cleared is shown by a letter on a starting signal.

In Switzerland, Luxemburg, Egypt, and Yugoslavia, route signals are not used for signalling the arrival. In Czechoslovakia, such signals are only very rarely employed.

In Denmark, route signals of the same form as the starting signals described in Chapter III (fig. 42) are employed, being usually placed immediately to the right or above the corresponding track. In recent years, many of these route signals have been discarded.

In Holland, a route signal is used for each route in such a manner that each home signal is placed above the track to which it refers.

When possible, main lines are protected against the movements on shunting lines by catch points or derailers. When it is impossible to protect them in this way, shunting signals are often placed alongside the track leading on to the main line.

Figures 51 to 57 show some examples of shunting signals serving to protect trains against the station shunting operations. Usually, these signals are not intended for trains. Figures 51 *a* to 57 *a* give the position : shunting not allowed, while figs. 51 *b* to 57 *b* show the position : shunting allowed. Figures 51 *a* and *b* show the German and Luxemburg signal; figures 52 *a* and *b* the corresponding Swedish signal, a form which is also employed in Norway, while the Dutch form, shown in figures 53 *a* and *b* differs slightly from the Swedish signal. Figures 54 *a*, *b* and 55 *a*, *b* show the Swiss shunting signal. Similar forms are employed in Denmark (see figures 56 *a*, *b* and 57 *a* and *b*). In Czechoslovakia and Yugoslavia a square signal is also used, but placed as shown in figures 58 *a* and *b*.

In some main stations in Sweden and Norway a special type of shunting signal has been introduced : warf signals of the position light type (fig. 59). These signals are used to regulate shunting movements, to allow of all these operations being controlled from a central cabin. The signal can give the following indications :

— *shunting not allowed :* during the day and at night two white lights next to each other (fig. 59 *a*);

— *shunting allowed :* during the day and at night, two white lights above one another (fig. 59 *b*);

— *shunting allowed at reduced speed :* during the day and at night, two white lights arranged obliquely (fig. 59 c).

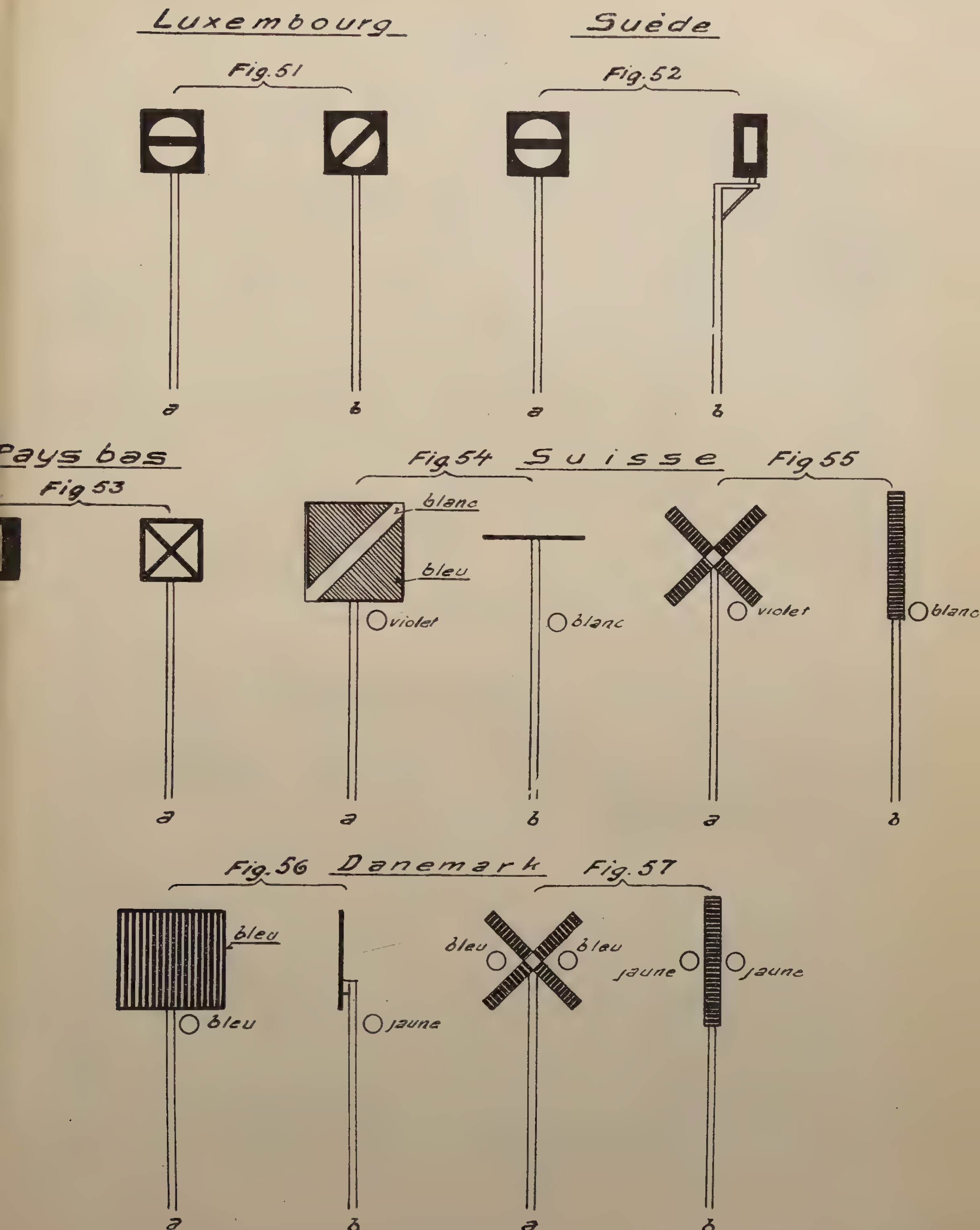
Position light shunting signals of another form are often used to give the same indications (fig. 60 *a-c*).

## CHAPTER V.

### Daylight signals.

Daylight signals are only used to any great extent on the Swedish and Norwegian railways. On some other railways dealt with in this Report, daylight signals have not been used very much, so that it is impossible to give any definite results of the rather scanty experiments that have been made. This applies to the railways of Czechoslovakia, Holland, Denmark and Finland. In the two last-mentioned countries, the Swedish types are used, a fairly brief description of which is given below.

Daylight signals, properly so-called, are not used on the other railways. This applies to the railways of Luxemburg, Yugoslavia, Egypt and Switzerland. In Switzerland daylight signals are only used in tunnels where the sunlight cannot affect the visibility, and where it is easy


Luxembourg
Fig. 51
a
b
Suède
Fig. 52
a
b
Pays bas
Fig 53
a
Fig 54
Suisse
Fig 55
blanc
bleu
violet
blanc
a
b
violet
blanc
a
b
Fig. 56
Danemark
Fig. 57
bleu
bleu
jaune
bleu
bleu
jaune
jaune
a
b
a
b

Figs. 51 to 57.

Fig. 58.

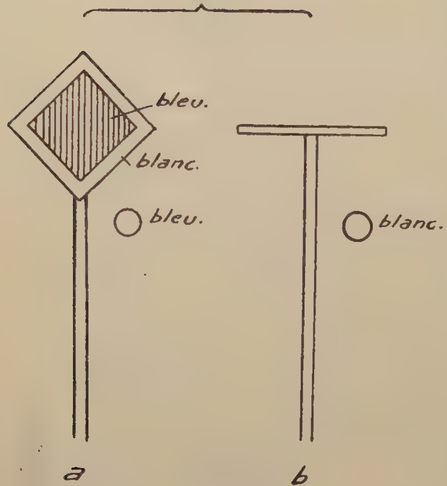



Fig. 59.

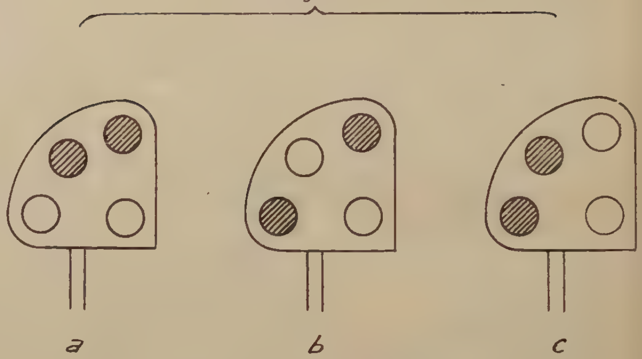
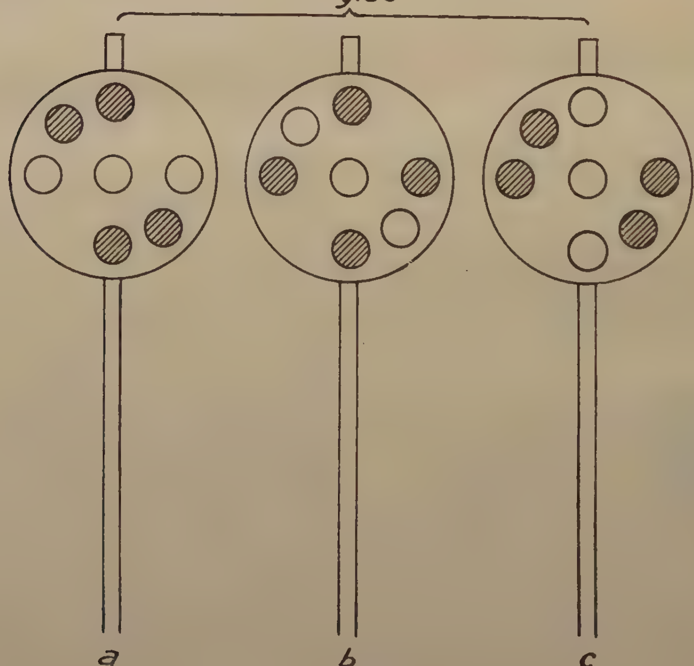



Fig. 60




Figs. 58 to 60.

to obtain sufficient visibility by using very simple lamps, without any lenses for concentrating the light.

The following table shows the types employed on the various railways, and gives the visibility obtained :

| Voltage. | | Consumption in watts. | Visibility. |
|---|---|---|---|
| Czechoslovakia | 16 | 35 | 800 to 1 000 m. (2 624 to 3 280 feet), red light.<br>400 to 600 m. (1 312 to 1 968 feet), white flashing light. |
| Sweden | 12<br>110<br>12<br>55 | 24<br>40<br>12<br>20 | 800 m. (2 624 feet).<br><br><br>Dwarf type shunting signals. |
| Norway | 10<br>10 | 40<br>20 | 1 000 m. (3 280 feet). |
| Denmark | 110 | 40 | |
| Finland | 12<br>127<br>220 | 40<br>40<br>40 | 600 to 800 m. (1 968 to 2 624 feet). |
| Holland | 10 to 12 | 15to25 | 700 m. (2 296 feet), red light.<br>350 m. (1 148 feet), green light. |

On all the railways the signals are employed to give the same indication as those described in the preceding chapter for night signals.

On the Swedish State Railways, the semaphore type of main signals and distant signals have to a large extent been replaced by daylight types. At the present time, 220 main electric daylight signals, 200 distant acetylene daylight signals, and 120 dwarf type shunting signals (see Chapter IV) have been introduced. A combination of lamps illustrated by figure 61 is used. Type *a*, *b* or *c* is used according to whether 1, 2, or 3 green lights are required. The lights may be steady or intermittent, according to the rules given in Chapter III.

Figure 62 shows the normal type of electric three-aspect signal. Sometimes an American type constructed of standard parts is used.

In block signals and home signals two lamps are used, one 12-volt, 40-watt lamp in front, and a 12-volt, 12-watt behind. The second lamp is provided with a protecting resistance. The 110-volt lamps do not last as long as lamps with a smaller voltage and consequently they are only employed in cases where if a lamp went out, no great inconvenience would be caused to the traffic (for instance, for starting signals). When a smaller number of volts is required, 110/12-volt step-down transformers, placed near the signals, are employed.

Daylight signals are visible at a distance of 800 m. in full sunlight. Only one type of signal is used, but lesser-powered lamps may be used if a visibility of 800 m. (2 624 feet) is not required. The brilliancy may be decreased by reducing the voltage, which ensures a longer life for the lamp.

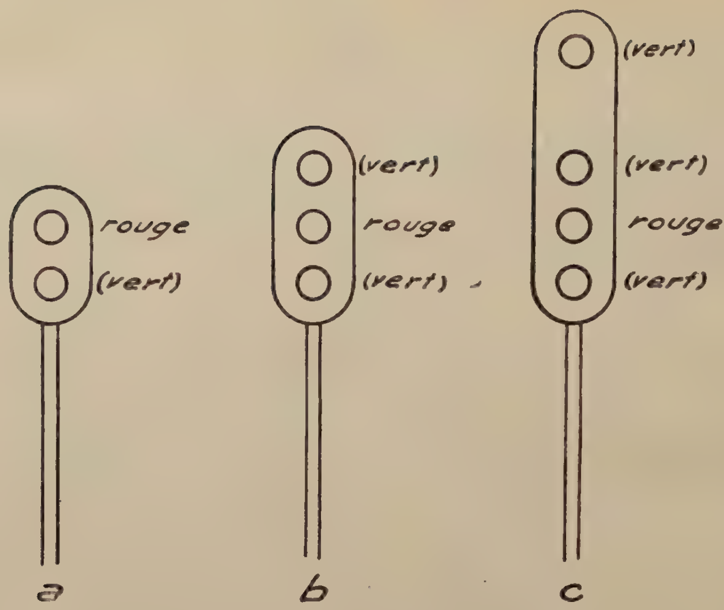
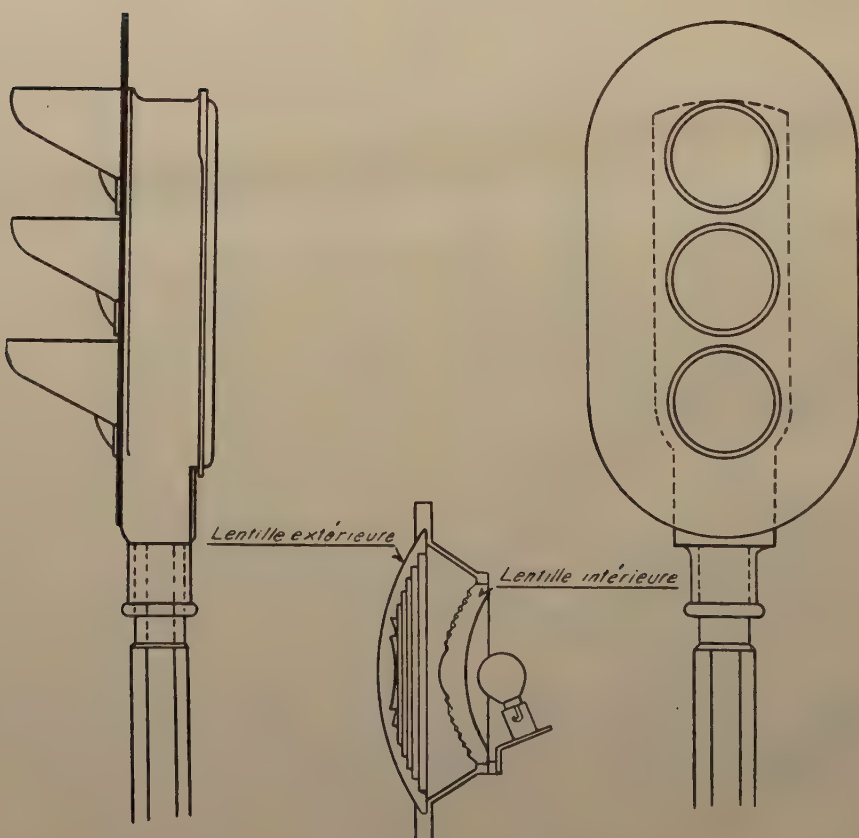



Fig. 61. — Daylight signals.




*Detail of a lantern.*

Fig. 62. — Daylight signal.

*Explanation of French terms* : Lentille extérieure = Outer lens. — Lentille intérieure = Inner lens.

The lenses are constructed so that a signal can be seen only a few yards away.

The signals are always lit, except when there are long intervals between trains.

The Administration of the Swedish State Railways considers that daylight signals are to be preferred, because their construction is simpler, the first costs are less, and visibility is as good and in certain atmospheric conditions still better. Moreover, snow and cold have no effect on daylight signals. Safety is greater, and the daylight signal will last an indefinite length of time because the signal does not wear out, except the lamps. However, the current consumed is greater for daylight signals. This consumption may be reduced by fixing devices which cause the signal to light up only when the train is approaching.

Acetylene lamps are used in distant signals, thus avoiding electrical connexions between the semaphores and the distant signals, eliminating trouble due to the effect of snow on the transmission. By using acetylene lamps, the distant signals are rendered independent of the main electric signals, which is an advantage from the point of view of safety.

In recent years, daylight signals have been used on a rather extensive scale on the Norwegian State Railways. In installations put down since 1921, daylight signals only are used.

For the main signals, the Swedish type is used — a coloured daylight signal — but in Norway electric lamps are also used in starting signals.

For home signals lamps are 10 volts, 40 watts and starting signals 10 volts, 20 watts. For route signals, the track cleared for departure is, as was described in the preceding chapter, indicated by a number. This may be given by small white lights forming a luminous number, for which purpose 110-volt, 15-watt lamps are used. The dwarf type shunting signals are the type described for Sweden.

In Norway, as in Sweden, daylight signals are preferred to semaphore or disc signals because they exhibit a better visibility. The opinion is, moreover, that, by using daylight signals, the causes of disorganisation of traffic are materially reduced, and the upkeep expenses are also less.

The Norwegian State Railways have given some particulars regarding the upkeep expenses of lamps. For a group of stations having 90 main signals and distant signals, with 260 lights, 109 lamps were used up in a year, that is to say, one lamp for each 2.3 lights.

## CHAPTER VI.

### Automatic block system.

It is only on a small number of the railways dealt with in this Report that the automatic block system has been used and then only on short-distance lines. The following is a list of the lines in question :

*Finnish State Railways :*

| | |
|---|---|
| Helsingfors-Fredriksberg<br>Viipuri-Liimatta | 3.6 km.<br>(2.24 miles). |

*Dutch Railways :*

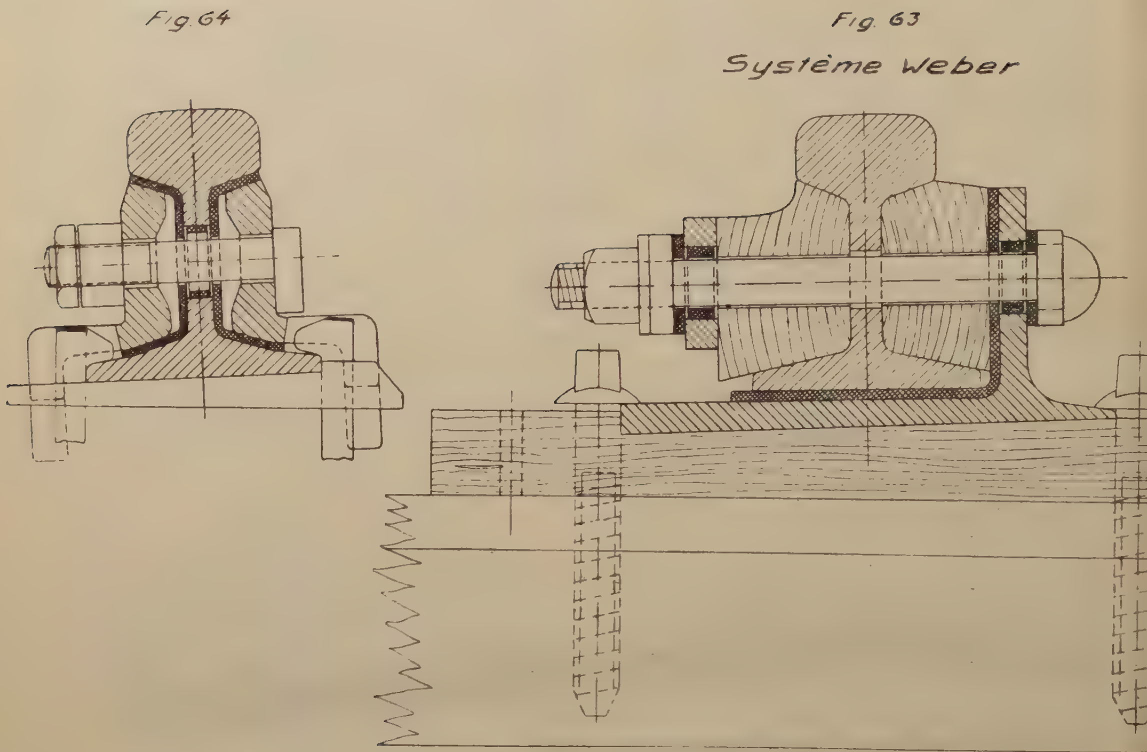
| | |
|---|---|
| Oudewater-Gouda<br>Berkum-Dedemsvaart | 23 km.<br>(14.3 miles). |

*Stockholm-Roslagen Railway :*

| | |
|---|---|
| Stockholm Ö-Stocksund | 4 km.<br>(2.5 miles). |

*Swedish State Railways :*

| | |
|---|---|
| Malmö-Arlöv<br>Göteborg-Olskroken<br>Norsholm-Kimstad | 23.1 km.<br>(14.35 miles). |




Figs. 63 and 64. — Insulated joints.

*Danish State Railways :*

Klampemborg-Skodsborg : 5.5 km. (3.42 miles).

Wherever the principle of the automatic block has been introduced, the generally-adopted principle of the absolute block has been replaced by that of the permissive block. This is the case in Holland, Sweden, and in Denmark, while on the Finnish Railways, the principle of the absolute block has also been retained for lines provided with automatic block.

Although the total length of lines provided with automatic block is very small, several different systems are used. In all these systems, a track current is used, carried by the two lines of rail. As the steel fish-plates do not guarantee electrical conductivity of the joints, because they offer too high a resistance to the low-voltage current employed, the rails are bonded by wires. The material of which these wires are made, and the manner in which they are attached to the rails, varies on different railways. In Holland and Denmark the wires are attached by means of conical wedges, provided with a groove in which the end of the wire is placed. All the joints are provided with two wires, of copper (in Holland) or of iron (in Denmark). Another method, often em-

ployed in Sweden, consists in using soldered connections, formed of a single copper wire or cable, soldered to the head of the rail, at the end of two adjacent lengths of rail. In this way, the connexions are not very long, and the resistance is consequently very low.

For insulated joints, up to quite recently wooden fish-plates have been used with a fibre sheet between the two ends of rail. It has been necessary, however, to replace them too often, because they are not sufficiently strong mechanically. For this reason, other systems are now used. In Holland and Denmark, the Weber joint is used (fig. 63) where the wooden fish-plates are reinforced by a strong steel part which is insulated from the rails by fibre sheets and by fibre bushes round the bolts. In another method, shown in figure 64, the steel fish-plates are retained, a piece of fibre being placed between the fish-plate and the rail, and a fibre bush round the bolt. This form is used in Sweden and Finland.

Very different solutions have been arrived at on different railways as regards the source of current, the system of signalling, the type of relay, etc., very different solutions have been adopted on the different lines and we give hereafter a description of the working of various systems of automatic block.

### Finland.

A very simple system has been introduced on the Finnish Railways (fig. 65). Daylight signals are used exclusively as block signals, which in the normal position indicate « line clear ». Four caustic soda cells in series are used as a source of current. The current passes along the rails and actuates the relay placed at the other end of the section. Alternating current of 220 volts stepped down to 14 volts flows, in this position of the relay, through the relay contacts and through the green lamp, authorising entry to the section. When a train occupies the insulated track, the wheels and the axle form a short-circuit, causing the relay to be released. In this position, the transformed alternating current flows through a back contact and through the red lamp of the signal. As soon as the train has left the insulated section, the signal resumes its normal position displaying green light. The lamps are 12-volt, 40-watt type. The relay is a Westinghouse 0.42-volt, 0.11-ampere type.

The length of a section varies between 0.6 and 2.1 km. (0.37 and 1.3 miles).

### Holland.

As a typical example a description is given below of the automatic block of the line Oudewater-Gouda. This line is divided into four blocks, the first and the last of which being special blocks combined with the starting signal of one of the stations and with the home signal of the other.

The signal permitting the train to enter a section is a semaphore signal almost corresponding to the block signal ordinarily used in Holland, with this sole exception that the arms are of American shape. The arm of the main signal is rounded at the end, while that of the distant signal is cut square.

In the normal position, the signals are clear.

As in Finland, caustic soda cells are used as a source of current. Two cells are connected in parallel in each section, so as to increase their life.

Like all the other appliances, the track relay is of the G. R. S. (General Railway Signal Company) type, with two windings

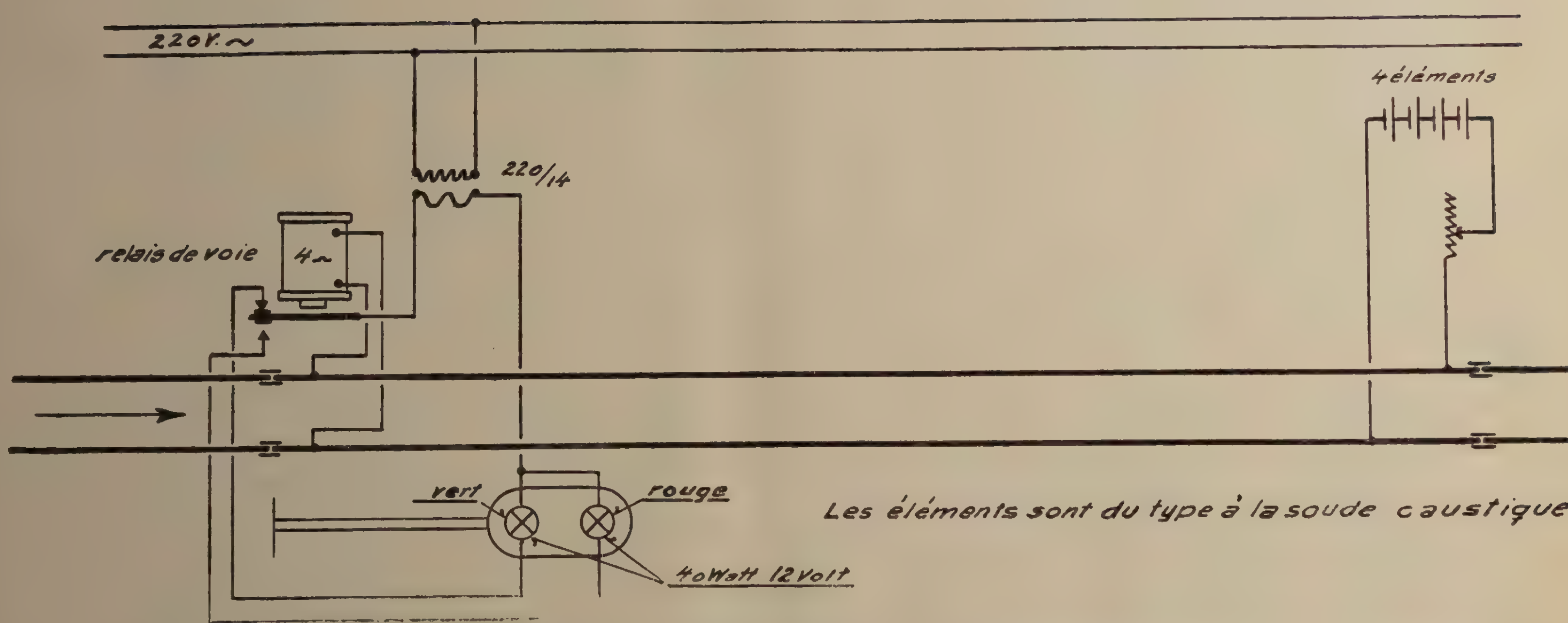



Fig. 65. — Automatic block system (Finland).

*Explanation of French terms* : 4 éléments = 4 cells, — Relais de voies = Track relay. — Vert = Green. — Rouge = Red. — Les éléments, etc. = The cells are of the caustic soda type.

and a resistance of 4 ohms. The pick-up is 60 milliamperes, the drop away is 30 milliamperes, and the operating current is 100 milliamperes. One kilometre (0.62 mile) is the maximum length allowed for a track circuit. The current of the track batteries is regulated by a small resistance (0.2 to 1.2 ohms) which is also variable so as to obtain the minimum intensity of current when the train is occupying the track.

A line relay is used in the system (fig. 66), and the current operating this relay is produced by a battery of 16 cells. The current passes through contacts on each track relay.

The construction of the line relays is similar to that of the track relays, but the resistance is 630 ohms, and the consumption 10 milliamperes.

A main signal is operated by a local circuit. The source of this current is 16 cells of the type mentioned above. As will be seen from the diagram, the current passes through the contact of the line relay in the energized position (line clear) and operates the signal motor.

This motor is a direct current series motor of 8 to 10 volts, using 2.5 amperes to operate the signal. The time required to set the signal blade at clear is 3 to 4 seconds. At the end of its movement, the blade closes a contact for the circuit of the clutch magnet, which possesses low resistance (26 ohms) and high resistance (630 ohms) windings. When the electro-magnet is energized, the low-resistance windings and the motor are connected in parallel, while the high-resistance winding is short-circuited. The motor and the electro-magnet together then consume 2.8 amperes. A pawl, actuated by the electro-magnet, prevents the motor shaft from running backwards. Just after the clutch magnet has been energized, the motor and the low-resistance winding of the electro-magnet (in parallel) are put in series with the high-resistance winding, which reduces the current for maintaining the line clear position to ± 10 milliamperes.

When the track is occupied, the line current is interrupted by the opening of one of the track relay contacts. The signal arm falls by its own weight into the danger position and remains there until the train has left the section. At the end of the movement it closes a contact (retained in position by a pawl device), enabling a current to pass through the motor and a resistance, and thus causing the motor to act as a dynamo and a brake. When the train has left the section, the line circuit is closed again, and the signal goes to clear.

It will be seen from the diagram that the clearing of a block signal is made dependent on the signal ahead going to danger, by including in the line relay circuit of the first signal a contact which is closed when the signal alread is at danger. In addition, in parallel to this contact, is connected another contact actuated by the line relay of the signal ahead. If this last-mentioned signal does not fall to danger, the first signal can only clear if this line relay is closed. This takes place when the train has left the second block. The first signal thus takes on the duties of the signal which is out of action, and consequently protects two blocks.

In order to make the distant signal dependent upon the block signal, the distant signal is provided with a special line relay the operating current of which has to pass through contacts closed when the arm of the block signal is set at « line clear ». The motor for operating the distant signal arm obtains its current through a special line relay contact. This

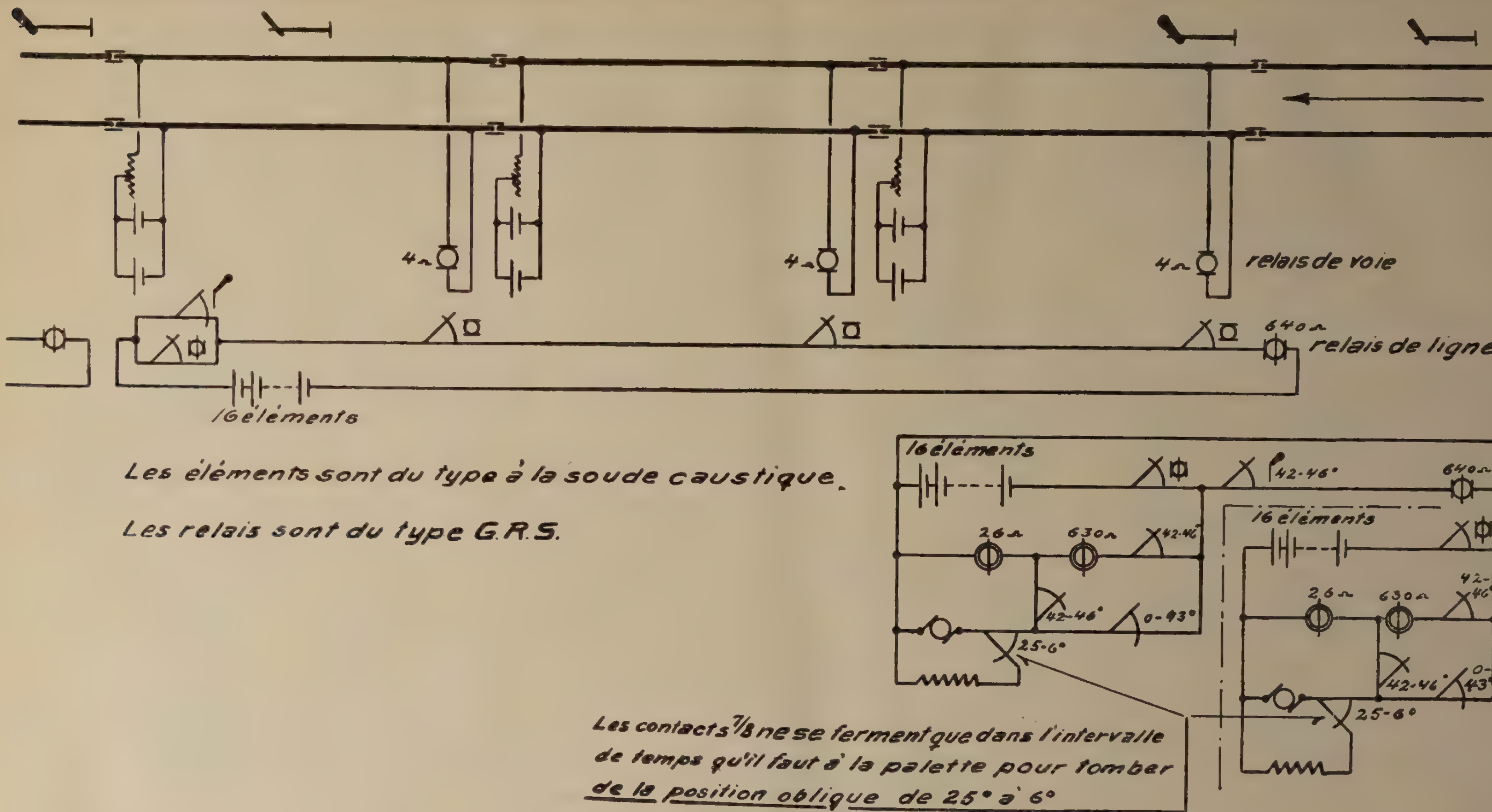



Fig. 66. — Automatic block system (Holland).

*Explanation of French terms* : Relais de voie = Track relay. — Relais de ligne = Line relay. — 16 éléments = 16 cells. — Les éléments sont, etc. = The cells are of the caustic soda type. — Les relais sont du type G. R. S. = The relays are of the G. R. S. type. — Les contacts, etc. = The contacts 7/8 only close in the interval of time taken by the signal arm to fall from the inclined position of 25° to 6°.

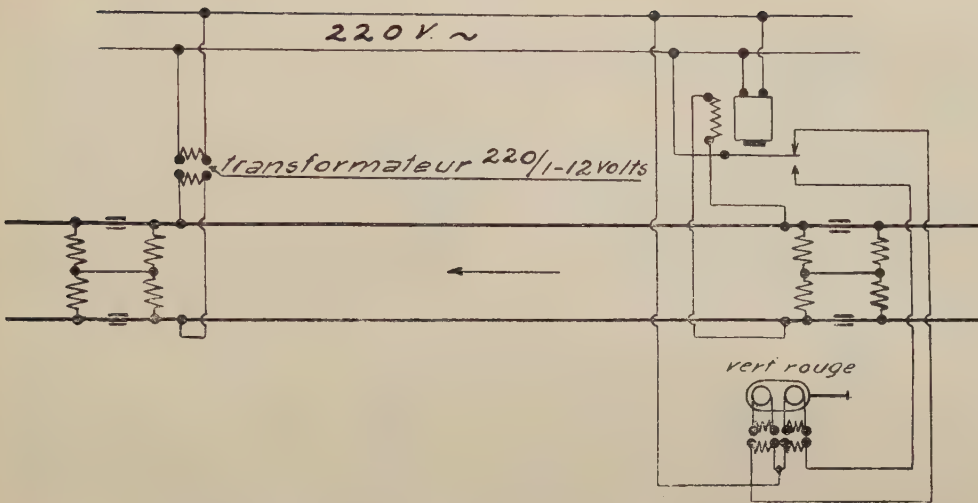



Fig. 67. — Automatic block system (Sweden, Roslagen Railway).

*Explanation of French terms*: Vert = Green. — Rouge = Red. — Transformateur, etc. = 220/1-12 vol ttransformer.

current is produced by a special battery placed near the distant signal.

This motor consumes a little more current (up to 2.8 amperes) than that of the block signal, and takes 7 to 8 seconds to set the signal at « line clear » (the angular movement is double that of the block signal).

### Sweden.

On the Stockholm-Roslagen line, the automatic block system has been introduced on the Stockholm Ö-Stocksund section. The traffic on this section is fairly heavy and in part it is dealt with by electric trains (about 70 trains a day in either direction).

The distance between Stockholm and Stocksund is 4.5 km. (2.8 miles) and this line is divided into six block sections. The length of a section varies between 539 and 718 m. (1 768 and 2 356 feet).

The home signal of a section is a daylight signal with two lights, a green one and a red one. Distant signals are not used.

The lamp circuit has a pressure of 12 volts and a power of 12 watts. The focus of the lamps may be adjusted very exactly so as to obtain sufficiently powerful signals despite the low power of the lamps.

The line is electrified. The power current is direct current at 650 volts, and the four track rails form a return for this current. For this reason, alternating current has been selected for operating the block apparatus, so as to avoid any irregularities which might be caused by the electric traction.

A diagram of the principle, for one section, is shown in figure 67. The track circuit is fed by a 220/1 to 12 volt transformer. The secondary winding of the transformer is provided with terminals for all voltages between 1 and 12, from which the track circuits are fed at 6 to 7 volts. A variable resistance of 1 ohm and 8 amperes to which the track current is regulated, is connected between one of the terminals and the rail. One part of the resistance should always be in circuit

so that the transformer will not be short circuited at the moment when the train arrives on the points from which the transformer is fed.

For the track a two-element two-position same type relay is used, a local winding of 220 volts and a track winding of 1.1 volt. The two windings of the relay, the local winding and the track circuit winding should be exactly in phase so as not to oppose one another. This arrangement of two two-phase currents has made it possible to obtain very great safety in the application of the system.

The phases are connected to the same rail for the two block sections. If one phase was connected to the same rail for two adjacent block sections, and the insulating joints were defective, the relay of one of the block sections would be actuated by the track current of the other section; by the arrangement described above, this drawback cannot occur, since the track current surges are unable to actuate a relay owing to phase difference.

The relays have six back contacts and four front contacts which makes it possible to arrange a large number of circuit combinations through the relay contacts.

Each signal light has a signal current transformer of the same type as described above.

This system differs from systems used heretofore, in that, in the normal position, the daylight signals are extinguished, which is effected by the use of electrical extinguishing apparatus This apparatus works on a current of 220 volts and is connected up as shown in figure 68. The extinguishing apparatus intended for a daylight signal is placed at the preceding end of the block section. As soon as a train has run through a section, the working current is connected to the extinguishing apparatus for the daylight signal behind, which remains extinguished. In this way it is possible to effect a considerable saving and at the same time to assure a longer life for the lamps.

The diagram represents three different cases of operating the block system. In the top figure, the track x-y is clear, the relays are energized, and the daylight signals are extinguished. The central figure shows the moment when a train reaches the first block section. The daylight signal behind it shows a red light and that in front lights up and shows a green light (line clear). The bottom figure shows the moment when the train is running through the first and third block sections; the first and third daylight, signals show red lights, and the signal situated between the two shows a green flashing light, this being a distant signal. The heavy black lines on the diagrams indicate the various circuits in the different cases.

Special devices are placed at the ends of the block sections so as to reduce the current in the section itself, while maintaining, however, good mechanical connexion between the different track sections for the return of the traction current. These devices are impedance coils fixed to the tracks.

The connexion between the rails and the impedance coils is formed by four copper conductors of 160 mm² (0.248 sq. inch). The ohmic resistance of the impedances is insignificant because the windings which are made of copper strip, have a cross-section of about 200 mm² (0.310 sq. inch). In order to balance the load of the electric traffic in one track with that on the other track, when the traffic is heavier on one track than on the other, and in order to use the four rails as return conductors, compensating circuits, consisting of 100 mm² (0.155 sq. inch) compensating cables are placed between the two impedance coils of one of

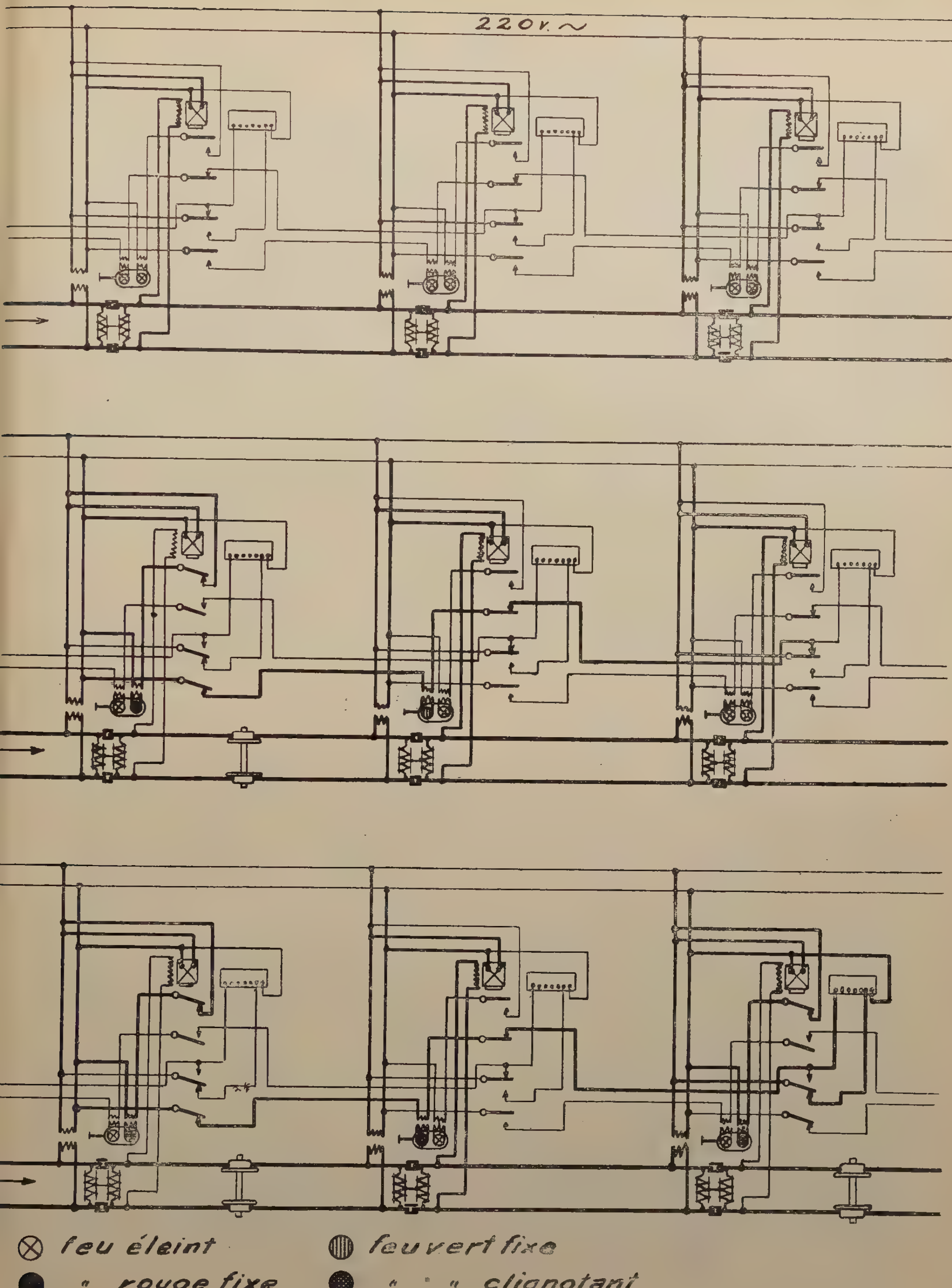



Fig. 68. — Automatic block system (Sweden, Roslagen Railway).

*Explanation of French terms* : Feu éteint = Light extinguished. — Feu rouge fixe = Steady red light. Feu vert fixe = Steady green light. — Feu vert clignotant = Green flashing light.

the tracks, and the impedance coils of the other track, and these compensating circuits are connected to the centre terminals of the impedance coils.

The whole of the installation between Stocksund and Stockholm, including the lighting of the signal cabin and part of the semaphores of Stockholm O consumes altogether about 25 kilowatt-hours per day, and taking into consideration the fact that the said current costs 0.10 Swedish crown per kilowatt-hour it will be seen that the running expenses have been brought very low.

On the *Swedish State Railways*, the automatic block system has been introduced on several small lines, both double and single track. On some of these lines, track currents are used with polarised direct current relays, having a resistance of 4 ohms; in this installation some of the signals are semaphores, while the others are daylight signals, both types being operated by relays.

On another portion of the State Railways, the Malmö-Arlöv line, track circuits are used, fed by alternating current, the pressure of which is stepped down to 4 volts, by 220/1 to 12-volt, 50-cycle transformers. As regards the track current, and the two-element track relays, the types are identical with those described above belonging to the Stockholm-Roslagen line, to the detailed description of which the reader is referred. The line begins with the starting signal and ends at the home signal of the following station, but it is the intention to extend the automatic block line, so that less important stations will form the sections. Daylight signals are employed as block signals.

Figure 69 shows a diagram of the installations in question. The length of a section is 1.0 to 1.2 km. (0.62 to 0.75 mile). The signalling systems differ somewhat from the system usually employed in the rest of Sweden, as will be seen from the following description.

The block signals have two lamps, but three different indications can be given by means of these signals : the green light means that the two following sections are clear; the green flashing light that the following section is clear and that the following signal is at danger; the red light means that the section behind the signal is occupied. The distant signals form a combination; they are, at one and the same time, a block signal and a distant signal, properly so called. These signals are only used in front of the stations, and can give three indications : white flashing-light, the home signal is at « clear »; green flashing-light, the home signal is at « danger » and, at the same time, there is a train on the block section between the distant signal and the home signal. For the distant signal to change to a green flashing-light the trains must not merely leave the section, but the home signal must be set at « danger ».

The diagram shows the following situation; a train is situated on the section between the distant signal and the home signal in front of Arlöv. The distant signal M shows a red light, the circuit for this light being closed by a back contact of the track relay. The signal K gives a green flashing-light because the flashing device is fed by a circuit closed by a back contact of the relay A-M. The signal C shows a green steady light, indicating that the two following sections are clear. The auxiliary phase in the track relay A-M is fed by a front contact of the relay itself or by a back contact on the distant signal relay, which is actuated by the home signal, and which, in the situation as shown, is energized. The current of the auxiliary phase is cut off just at the moment when the home signal is set at « danger ».

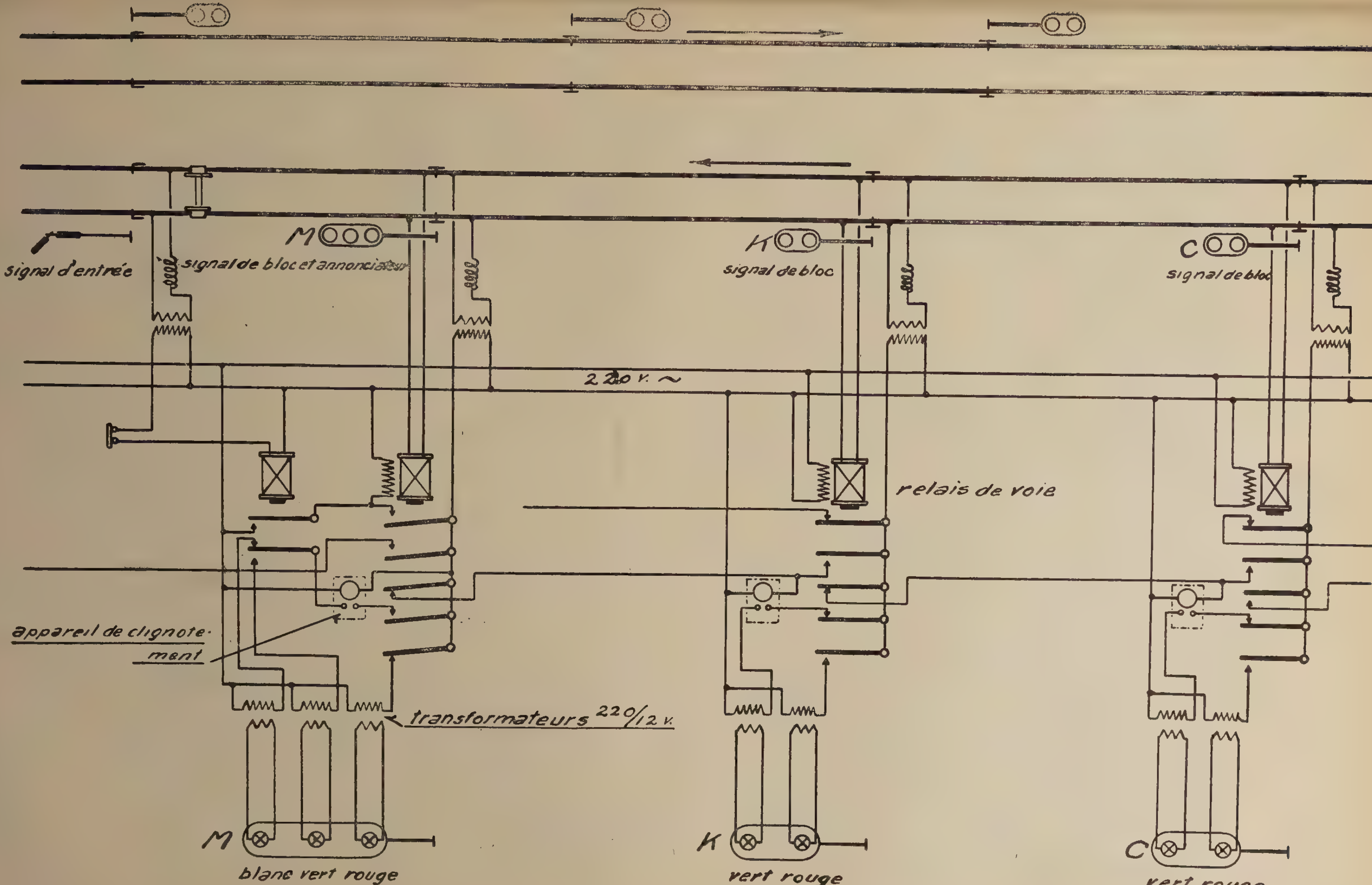



Fig. 69. — Automatic block system (Sweden, State Railways).

*Explanation of French terms* : Signal d'entrée = Home s gnal. — Signal de bloc et annonciateur = Block and distant signal. — Signal de bloc = Block signal. — Relais de voie = Track elay. Appareil de clignotement = Flashing-light apparatus. — Transformateurs = Transformers. — Blanc = White. — Vert = Green. — Rouge = Red.

Denmark.

On the Copenhagen-Elsinore line, an automatic block has been installed between the two stations Klampenborg and Skodsborg. This section belongs to a line provided with a manual-operated block system, and the distance between Klampenborg and Skodsborg was divided into three block sections. This subdivision was retained after the adoption of the automatic block system. Figure 70 shows a diagram of a section of this line. In order to avoid glaring differences in the signalling systems used on the automatic block line and on the contiguous manual operated block lines, the existing block signals have been retained — these are of the semaphore type and the normal position is at danger. The principle has also been adhered to, that a signal should remain at clear until the last axle of the train has passed it. With these objects in view, small track sections 30 m. (98 feet) in length have had to be introduced after each block signal, and the system has had to be supplemented by some devices which have rather complicated the installation.

The diagram shows the normal situation when all the section is clear, and the parts through which current normally flows are shown in heavy lines. The contacts actuated by the different relays and signals are marked, respectively, by the signs of the relay or of the signal. The following is a description of the operation of the system when a train passes on the section in the direction indicated.

When this first axle passes the joint J 1. the signal is set at « clear » by the following circuit : battery P, contact 2, relay R 2, contact 1 and return. The signal motor is thus fed by the same battery and the signal clears. When the motor has set the signal at clear, the contact 7 is opened, but, so long as the relay R 2 (brake relay) is energized, the signal remains at « clear ». When the signal is at « clear » the distant signal is also set at « clear » because the relay R 3 is energised and because, by this very fact, contact 9 is opened. The train therefore passes the two signals at « clear » and enters the following track. At this moment, the relay R 4 is de-energized, the relay R 5 is energized, and another retaining circuit is made at this moment, the current passing through the contacts 5, 4, 3, relay 2, contact 1 and return, so that the signal remains at « clear » so long as there is an axle on the small section J2 J3.

It should be noted that the winding of the relay R 5 is designed so that the relay cannot be energized except by the action of a short-circuit caused by the actual presence of an axle on the track circuit limited by the joints J2 J3. This relay is de-energized as soon as the train has cleared the short section, by the closing of the contact 12 of the energized track relay R 4, which shunts the winding of the relay R 5. The function of the relay R 5 is to control by its energization the actual presence of the train, and to maintain the signal at « clear ».

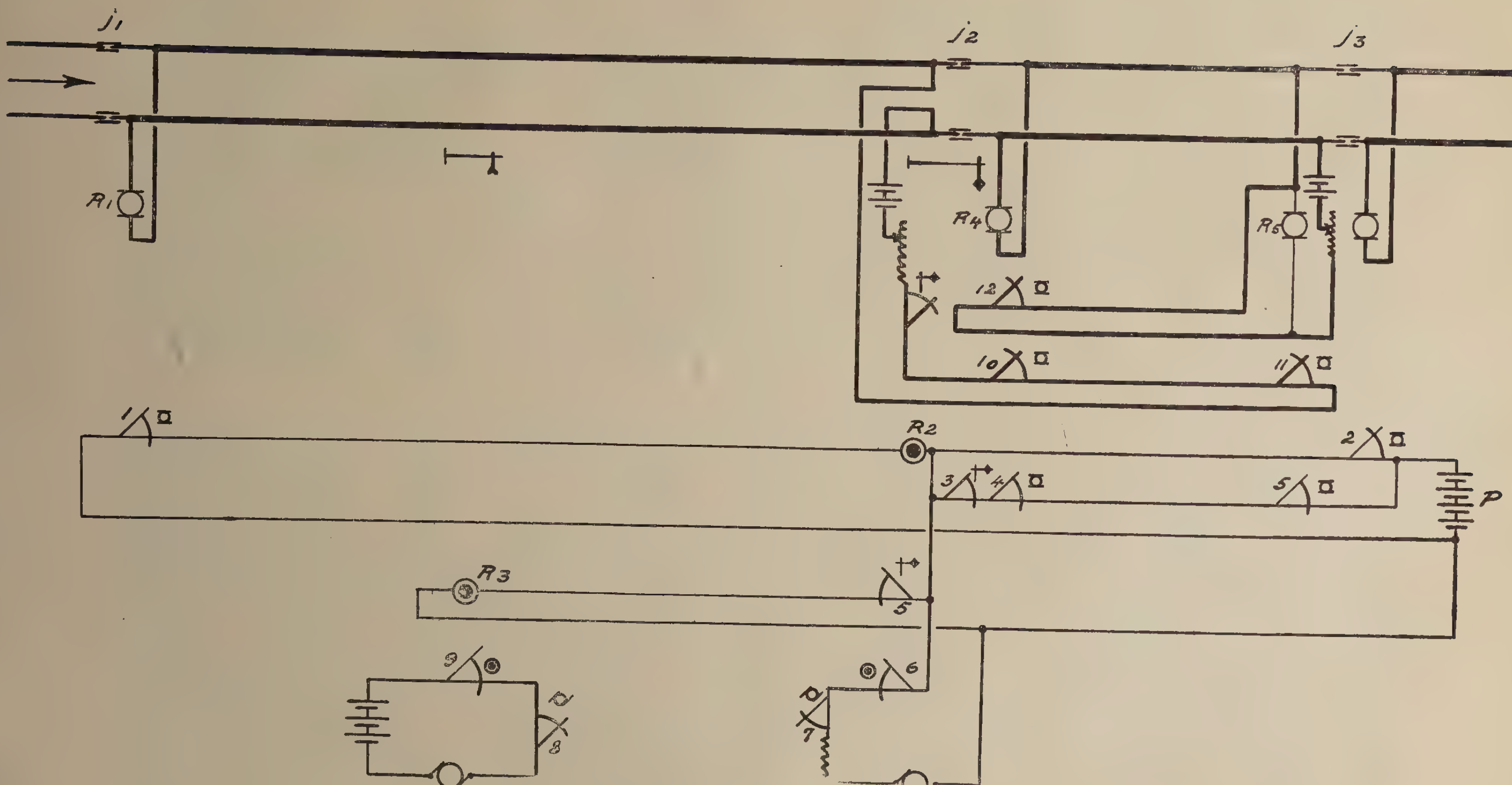
When the train has completely cleared the track circuits J2 J3, the circuit maintaining the signal at « clear » is opened, and the signal is set at « danger ».

The following results have been obtained by the system just described :

— the signals can only be set at « clear » on the approach of the train, when the track section below is clear.

— the automatic setting of the semaphore at « danger » takes place when the end of the train has cleared the signal.

— after the passage of a train, the setting of the block signals at « danger » is controlled in such a way that a signal above can only be set at « clear » if the




The cells are of the caustic soda type. The relays are of the Hall type.

Fig. 7C. — Automatic block system (Denmark).

signal below is set fully at « danger » and if there is no train between the two sections.

The object of this installation was to dispense with the employees operating the manual block in the two block stations. The employees in one of these block stations also worked the level-crossing barriers, and consequently, it became necessary to actuate these barriers electrically also; the barriers are open and they close automatically on the approach of a train; the block signals also serve as protecting signals for the level-crossing, in such a way that the signals cannot be set at « clear » if the barriers are not closed. Judging that a full description of these arrangements is outside the scope of the present subject, we give here only a brief description of the system employed.

The conditions for opening the barriers depend upon a relay, which normally is energized. When, the relay is de-energized, the barriers close.

The operation of closing the barriers takes place in three stages: when the relay is de-energized, the barriers are at once partly closed remaining at a certain angle, and a bell begins to ring as soon as the barriers leave their normal position. They remain several seconds in the partly-open position, so as to indicate to those passing to keep clear of the barrier. When the time during which the barriers remain in the partly-open position expires, the barriers close slowly.

When the train has passed the level-crossing, the relay is re-energized, and the barriers open in a single movement, passing directly from the closed position to the open position.

Caustic soda cells are used as a source of current. The batteries employed vary greatly in size and capacity. For the track current batteries three cells in series, with a capacity of 600 ampere-hours are normally used. For the track current of short sections, the same type of cell is used, but only two cells are used in series. The signal is worked by a battery of 18 cells with a capacity of 200 ampere-hours.

The track relays and the line relays are of the Hall type with an exceedingly small consumption, only about 0.05 watt.

Several of the above-described installations have not been long enough in existence to be able to provide exact information as to the regularity of their working. This is the case in Finland and in Denmark. As regards the Dutch and Swedish installations, information has been received to the effect that very few troubles occur. The commonest trouble is the breaking of connexions. At the same time,on railways where the conical wedge type has been adopted — see above — the reservation has been made that such cases of rupture have hardly ever caused the « block system » to break down. Relay troubles or defects in the insulated joints hardly ever occur. Sleepers impregnated with creosote are employed an all the railways.

As regards the Dutch installations, the American appliances of the *General Railway Signal Company* are employed. In Sweden and Finland most of the material has been supplied by the *Signalbolaget*, a branch of the L. M. Ericsson Telephone manufacturing firm of Stockholm. The type of relay made by this firm is similar to the American « Union Switch » type. American relays supplied by the *G. R. S.* are much used on the State Railways. In Denmark, French appliances, supplied by the *Compagnie de Signaux et d'Entreprises électriques*, of Paris, are used,

In Norway, a block system without

track relays is used. This system may be denoted as « semi-automatic ». Two block levers, locked with the signal levers, have been placed in the two end stations of a block section. A train cannot leave one block section except when current passes through the block relays on the two sections which are coupled in series. When a station has set a starting signal at « line clear », the current passing through the two block relays is interrupted and is not re-established until the train has entered the other station, the block lever has been put into normal position, and the train, after having occupied two contiguous sections, has left one of these sections.

## CHAPTER VII.

### General considerations.

#### The signalling system.

It follows from the description given in the preceding chapters that the signalling systems employed in the various countries are fairly different. Leaving aside, however, these small divergences, it is still possible to find some common features in the signalling systems of the described Report. On the other hand, as already described, Egypt has based its system on the English system of signalling.

If the common features are picked out from these different systems, it will be very soon found that they form a very simple signalling unit.

This simplicity is due particularly to the fact that, in the countries in question, the absolute block system has been adopted, with the exception of those lines provided with automatic block, on which the principle of permissive block is applied. By utilising the principle of the absolute block, the problem of « signalling in front of dangerous points » becomes fairly simple.

On almost all the fast traffic lines the disc forms of signal have gradually been discarded for main signals, and semaphore forms have been adopted. In the preceding chapters, it has been shown that on some railways the arm is placed on the track side of the signal post, while on other railways it is placed on the opposite side of the post. The first method is preferable because it enables the distance between the track and the signal to be reduced, which may be an important matter when there are telegraph poles or posts along the track.

Opinions differ as regards the number of indications which should be given by signals protecting a dangerous point. Experience has shown, however, that a signal giving three indications is particularly suitable for fast traffic lines. Originally three indications were used for example in England: line clear, slow down, and danger. Later on modifications were introduced on most of the railways so as to signal: line clear for the main line, one or two indications for line clear on one or more branch lines, and an indication for danger. In Germany, the recent tendency has been to reduce these four indications, and to only give three, one indication alone being used for all the branch lines. The most usual method consists in signalling danger (stop) by a horizontal arm (at night, a red light), and line clear for the main line by an inclined arm (at night, a green light), while for arrival on a branch line two inclined arms are employed (two green lights). This arrangement offers the disadvantage that if a light goes out the meaning of the signal may be changed: two green lights changing into one green light, indicating line clear on

the main line, whereas it is the branch line which is really clear.

It is evidently recommendable that some solution should be found which would enable the disadvantage that might be caused by the extinguishing of a light to be avoided. Different methods of obviating this drawback have been considered. In Norway, two arms are used to indicate line clear on the main line and one arm to indicate line clear on the branch line; the result of this arrangement is, however, that it is equally necessary to use a double-arm signal as a protecting signal in front of a point where there is no branch line, for instance, for a block signal.

In Finland, a very interesting solution of this problem has been applied; signals of the same form as those described are utilised, flashing-lights being employed in such a manner as to indicate line clear on the main line by a green flashing-light, and line clear on a branch line by two steady green lights.

In Holland the same disadvantage has been obviated by placing in front of each turn-out (junction or station with more than one arrival line) a bracket signal with as many signals as there are lines, and the permitted speed is marked by the height of the post and by boards fixed to the posts. In Denmark the idea of giving the indications main line clear and branch line clear by means of the home signal has been abandoned. The signal is also an ordinary signal with three indications but this signal is employed to distinguish between line clear for a non-stop train and for a stopping train.

In this system the disadvantage in question is avoided because in no case is either of the home signal arms placed out of sight. The danger signal is consequently indicated by two lights. In Denmark, on the other hand, the opinion is that the indications « main line » or « branch line » are usually superfluous because the Danish Regulations lay down that the drivers should know beforehand on what line they are to enter the station. Nevertheless, efforts have been made to give the signal protecting the first points a very distinct form, and recently, in certain cases, this points signal has been repeated on the home signal post.

Whereas the home signal for all the countries dealt with in this Report has the form of a semaphore signal, the disc form has been preserved to a fairly considerable extent for the distant signal. Efforts have often been made to obviate the well-known disadvantage by which the indication « line clear » given by this signal is represented by a negative indication.

In many countries the place of the said signal is marked by a screen. On the Bavarian railways, the danger signal is given by a circular disc, but the signal « line clear » is given by an inclined arm obtained by bending the disc along two oblique lines. On other railways, as in Denmark and Holland, semaphore signals are used, the arm being given a form which distinguishes it from that of the main signal.

On the Finnish Railways, where the speed does not exceed 80 km. (50 miles) per hour, it has not been considered necessary to repeat the home signals by distant signals, in cases where a visibility of 500 m. (1 640 feet) at least can be obtained for the home signal.

On almost all the other railways, the distant signal has become compulsory for all fast traffic lines, and on some railways where the maximum speed is very high, starting signals with three positions are being introduced. In all the countries,

it has been recognised that it is important to give the main signals and distant signals forms which are quite distinct from one another both during the day and at night. For this purpose, two lights arranged obliquely are used, for example, in Germany, Luxemburg, and Norway. At one time, the solution of this problem offered some difficulty, because the number of colours which can be used for signal lights is somewhat limited; however, now that flashing-light apparatus, operating very reliably, are made, the problem has become easier to solve. In Denmark, the flashing-light has been introduced in all the distant signals, and in these signals alone.

By adopting the flashing-light, the number of night signals which are utilisable can be doubled. On many railways, however, the flashing-light has been used indiscriminately, sometimes for main signals and sometimes for distant signals. This procedure has no doubt resulted in a considerable reduction of the consumption costs of the lamps, but at the same time it removes the possibility of making the signalling system clearer by the use of the flashing-light.

As the descriptions given in the preceding chapter have shown, the three-position distant signal is only used to a very small extent. On some railways, for example those of Switzerland, the opinion is that it is desirable to use the three positions: one for warning, and two for the line clear positions of the home signal. This modification, however, would be too costly, and the question has been shelved until a more favourable time. In Luxemburg, on the other hand, it has been considered necessary to change the distant signal into a three position signal. The old disc form has been retained on these railways, and an auxiliary arm has been added, which is only in sight for line clear on a branch line. A similar signal has been used on one line in Sweden. Another solution has been adopted on the Dutch Railways: a double-arm distant signal with three indications. In Denmark a commission, appointed to study signalling problems, has come to the conclusion that a three-position distant signal is useless at this time on these railways, where the speed does not exceed 90 km. (56 miles) an hour.

As regards the distance at which the home signal and the starting signal should be placed, very different rules are followed on the various railways. The rule which is applied most frequently is that consisting in placing the home signal a fairly short distance in front of the first points, at the same time taking into consideration — especially on single line railways — whether it is necessary to carry out shunting operations on the arrival line, between the home signal and the first points. As regards the distant signal, the object has been to fix the distance in a rational fashion according to the gradient, so as to place the signal in question at the spot where the brakes should be applied. In theory this method is very logical and may give excellent results on lines where the trains are all of uniform formation. The difficulties are much greater, however, on a mixed traffic line, the distance being in fact not only a function of the gradient but also of the percentage of the braked axles and the construction of the brakes. If a distant signal is placed at a distance considered as the maximum braking distance for one train, the signal does not necessarily indicate to other trains the spot at which the brakes should be applied, but it will enable those trains to locate their position, and after all the driver should

be familiar with all the local conditions. Arguing on this basis, the idea of placing the distant signal at different distances has been abandoned in Denmark; it is placed at a fixed distance of 400 m. (1 312 feet) in front of the home signal, and the distant signal is supplemented by warning boards also placed at fixed distances of 600, 800, and 1 000 m. (1 968, 2 624, and 3 280 feet). The warning boards are illuminated sufficiently by the locomotive headlights. This arrangement has given very satisfactory results.

On the Dutch Railways, a similar arrangement is used, with this difference that the distance between the main signal and the corresponding distant signal has been increased; warning boards placed at fixed distance have also been introduced on these railways.

Usually the stations are provided with starting signals. Formerly on the various railways a common post was employed with several arms, one arm for each departure track. This method has been abandoned on most railways because the signals did not provide the driver with a sufficiently clear indication but required some judgment on his part. Nowadays, a starting signal is mostly placed at the side of each departure track. Different measures have been adopted to indicate the line prepared for departure when there is more than one line leaving the station. On some railways, the signal post is provided with more than one arm so as to be able to distinguish between the indication for departure on the main line and that on a branch line. Other railways prefer to place a one-arm signal at the side of each departure track, and to supplement the track signals by route signals, one signal at the side of each line. When this last method is used a letter is sometimes placed on the post of the starting signal to indicate the line for which the departure track is prepared. In some cases the starting signal has to be placed at such a short distance from the end of the platforms that a train arriving in the station is bound to run past the starting signal. To obviate this disadvantage, the possibility is being considered in Denmark of giving a special form to the inside starting signals of a station, and to replace the red danger light by the yellow light, the form of the main signal being retained only for the route signals.

On several railways the starting signals are preceded by distant signals. These signals have generally the same form as the distant signals preceding the home signals, and the distant signal placed in front of a starting signal is very often combined with the home signal. In Denmark, for instance, this combination is compulsory, so that it forms an integral part of the home signal even when the starting signal is dispensed with. This last form of signalling is used considerably on single line railways.

There are still some railways where the white light is used for « line clear ». This is the case in Czechoslovakia and Holland, and on these railways the oft-discussed disadvantage of this light is not considered to be so great as to warrant changing to another colour.

In the opinion of the reporters, it would be best to avoid the use of the white light in all signals which are important for fast traffic; this light should only be used to give indications of a secondary importance. As a matter of fact, the white light is very suitable for many indications which may be usefully given in stations, especially when more than one light may be used to form a figure, for instance, in the case of shunting signals.

Different forms of shunting signals

are used. The signals are often merely used to protect main lines against shunting operations, in which case they constitute so to speak « barrier signals ». This is the case for example in Germany and Luxemburg. In recent years, however, new forms are being introduced, as in Sweden and Norway, enabling the shunting operations to be controlled. These signals are combined with locking devices in such a way that a signal can only allow access to a section of the station when the section is clear and when the points are locked. This method enables the number of employees to be reduced considerably, all the shunting operations being controlled from a central cabin.

### Lighting the signals.

On many railways, oil lamps are gradually being replaced by electric lighting. This procedure is being followed principally in countries where electrification is very extensive as in Switzerland, Sweden, and Norway. The lamps have not yet been standardised, but the most usual types for main signals are those of 15 to 25 watts.

Acetylene lighting is particularly common in the Scandinavian countries where the «Aga» system of flashing-light signals is employed. The number of periods varies on the different railways between 60 and 80 per minute, and the period of flash varies between 0.1 to 0.5 of the total period.

### Daylight signals.

In recent years the various types of daylight signals have been considerably developed and they are used to a very large extent on the Swedish and Norvegian railways in particular. The use of daylight signals avoids the disadvantages often arising on lines which have been electrified, where the lattice poles carrying the overhead conductors have often been found detrimental to the visibility of the signals. In Switzerland, where daylight signals are not used, the opinion is held that the view of the signal arm is only obstructed by the poles in isolated cases, and that it is possible to avoid this drawback by selecting signal posts of a suitable height and by displacinq a little those poles which are in front of the signals. In Holland the opinion is also that electrification has been detrimental to the visibility of the signals, but it has not been thought necessary to consider other forms of signals. In Sweden and Norway it has also been recognised that the visibility of the signals has been diminished on the electrified lines and it is for the purpose, among others, of obviating this disadvantage that semaphore signals have been replaced to a fairly considerable extent by daylight signals. In Czechoslovakia efforts are also being made to avoid these disadvantages by employing the methods used in Switzerland and Sweden.

On most of the railways where daylight signals have been introduced, lanterns of American type are usually employed, having an inner coloured lens and an outer plain lens. This construction avoids wrong indications being caused by the reflection of the sun. The main difficulty resides in the fact that the beam of light has to be very narrow in order to produce the desired effect. In short radius curves, the visibility of this signal may be reduced too much. The modern construction of a daylight signal enables the signal to be seen even when the train stops immediately in front of it.

By using modern types of daylight signals it is possible to obtain a perfectly

satisfactory visibility, it being possible at the same time to simplify the apparatus; on the other hand it should be taken into consideration that it is an advantage to have daylight signals giving the same indications, both in the daytime and at night. The most usual type of lamp is the 40-watt type, and by slightly reducing the voltage it is possible to increase its life in a very effective manner. Experiments which have been made in countries where daylight signals are much in use have shown that sources of breakdown are fairly considerably reduced, and that the maintenance expenses are diminished.

### Automatic block.

Seeing that the experience acquired has been obtained on very few railways, with very small installations, it is difficult to make a rational comparison of the advantages and defects of the various principles. It is clear, however, that the entire operation of an automatic block system depends in the first place on the working of the relays. This has been recognised for many years in America where the manufacture of both direct current relays and alternating current relays is subject to very exact conditions. On most of the lines mentioned in Chapter VI, either American relays are used, or relays made in Europe but satisfying the conditions laid down in the regulations of the American Railway Association, Signal Section.

It follows from the descriptions given in Chapter VI that the automatic block system may be simplified considerably by using daylight signals, especially when a source of direct current is available, when all signal motors and batteries may be dispensed with.

### Summary.

Efforts should be made to form the signalling system in such a fashion that the number of indications is limited to that which is strictly necessary. The introduction of signals which can give more indications than are absolutely indispensable to inform the driver entails the risk of making the apparatus too complicated, while at the same time producing a confusion in the mind of the man who has to obey the signal.

As a main signal for protecting a dangerous point: home signal or block signal, etc., the semaphore signal in the opinion of the Reporter is incontestably superior to the disc forms.

The interval separating the signal arm from the corresponding track should be as small as possible, which is achieved, for example, by placing it on the side of the post facing the corresponding track. The application of this measure does not constitute a fixed rule, but it may be of importance where there are lattice poles or telegraph poles along the track.

On fast traffic lines it is to be recommended that the home signals should be formed so that they can give three indications, one referring to absolute stop, the other for passing the signal at normal speed, and the third being given different meanings relating either to the line (main or branch) or to the passing of the signal (without stop or otherwise).

The most suitable lights for main and distant signals are red, yellow and green. The white light, on the other hand, possesses disadvantages when it is compared with the other signal lights, and the use of this colour in main signals and distant signals is to be avoiled whenever its character has not been altered by transforming it for example, from a steady light to a flashing-light.

It is to be recommended that the signal should be constructed in such a fashion that if the light goes out, the indication of the signal is not changed to one which may give rise to a dangerous situation.

The distant signal should have a form such that, day or night, it can be readily distinguished from the main signal. This may be effected, for instance, by using a flashing-light.

On fast traffic lines, the distant signal may be regarded as indispensable.

Usually, a two-position distant signal is sufficient. For very fast traffic lines it may be advisable to use a distant signal which can give three indications.

On lines with uniform traffic, it is to be recommended that the position of the distant signal is such that it denotes also the point at which the brakes should be applied. For mixed traffic lines, just as satisfactory results may also be obtained by placing the signals at a fixed distance in front of the main signals.

It is to be recommended that warning boards should be placed at fixed distances in front of the main signal. This measure is of very great importance, especially when the distance between the distant signal and the main signal is relatively small. The warning boards should be placed so that they will be sufficiently illuminated by the headlights of the locomotive.

The starting signals should preferably be placed immediately alongside the tracks to which they refer.

If departure from one track by more than one line leaving the station is possible, the departure indication for this track should be supplemented by a route indication, given either by a special signal or by devices placed on the signal post of the track in question.

The starting signal should be so placed that an arriving train is not obliged to run past it. However, if this is not possible, the use of the absolute stop indication by means of the starting signal should be avoided.

The types and colours of shunting signals should be such that they cannot be confused with those of the main signals.

It is desirable that shunting operations be based on a special system of signalling, and with this object in view, it is to be recommended that a study should be made of the control of shunting operations as carried out on the Swedish and Norwegian railways by means of dwarf-type signals.

It is recommendable to substitute electricity or acetylene for mineral oil. For electric light of the main signals, two lamps in parallel should be used for each light, which should be fitted with devices for indicating when the lamps have gone out.

The use of acetylene for various types of signals makes the system independent of a source of electric current, which is an advantage when there is no such supply.

Compared with semaphore signals, daylight signals possess the advantage of being more simple and of giving the same indications both day and night.

Two lamps in parallel for each light should be used in main signals.

The lamps should be 40-watt lamps, and it is recommended that they should be slightly underrun so as to increase their life.

The lenses should be constructed so as to concentrate the light strongly, and to avoid phantom indications being caused by the sun's reflection.

When the signal is placed on a short radius curve, the dispersion of the rays

should be increased in the direction of the curve.

By using modern types, it is possible to obtain a perfectly satisfactory visibility.

It is to be recommended that the daylight signal should be introduced especially on electrified lines, where the visibility of ordinary signals is affected by lattice poles, etc.

It is to be recommended that efforts should be made to lay down standards for the construction of relays intended for use in automatic block systems.

The use of daylight signals as block signals is to be recommended because they contribute materially to simplifying the appliances.

# CURRENT PRACTICE.

[ 621. 133.7 (.42 ]

## Description of the A. C. F. I. feed water heater fitted to Pacific engine No. 2580 « Shotover » of the London and North Eastern Railway.

Figs. 1 to 4, pp. 3220 to 3223.

An improved type of A. C. F. I. feed water heating apparatus has recently been fitted to *Pacific* type engines No. 2580 « Shotover », and No. 2576 « White Knight » on the London & North Eastern Railway.

The standard type of A. C. F. I heaters, consisting of two circular chambers located on top of the boiler behind the chimney have been superseded by a heater arranged to fit into the smokebox, ahead of the chimney. This arrangement eliminates heat losses by radiation, and reference to the photographs will show that the appearance of the locomotive is not impaired.

The system used is the « Integral Type ». This system differs from that previously used (the R. M. type), in that the condensation of the exhaust steam by the cold feed water takes place at the pressure of the exhaust steam, instead of at atmospheric pressure, as in the R. M. system, giving a correspondingly increased temperature of feed. No control valve is fitted on the exhaust steam pipe between the blast pipe and heater. Flooding of the heater is prevented by the oil drain and security valve « H ». This is a piston type of valve proportioned to balance the weight of the valve, plus load on valve due to steam pressure in the heater, against a colum of oil and water about one metre in height. If the height of this column is increased in the pipe above the pre-arranged height, the extra weight of oil and water lifts the valve and allows the excess oil and water to run to waste.

A similar type of valve « K » is fitted to the hot water chamber to control the return of excess water to the suction vessel. A horizontal tandem pump, consisting of a steam cylinder driving direct two water cylinders, one hot water and one could water, is fitted. The cold water cylinder of the pump lifts cold water from the suction vessel « A », whence it has flowed by gravity from the tender, into the mixing chamber of heater « B ». The cold water is introduced into the mixing chamber in the form of a fine rose spray, where it mingles with, and condenses the exhaust steam from the blast pipe, that has passed through the oil separators « C. $C_1$. », thus absorbing the heat of the exhaust steam, and increasing the weight of water by the weight of steam condensed.

The exhaust steam from the Westinghouse pump and the A. C. F. I. pump is also turned into the mixing chamber, thus increasing the efficiency of the apparatus.


Fig. 1.

The hot water then flows through the connection pipe « D » to the hot water chamber « E , which it fills up to the height of the overflow pipe « F ». By gravity the hot water flows to hot water cylinder of pump, which delivers same to boiler through the clack valve « G ».

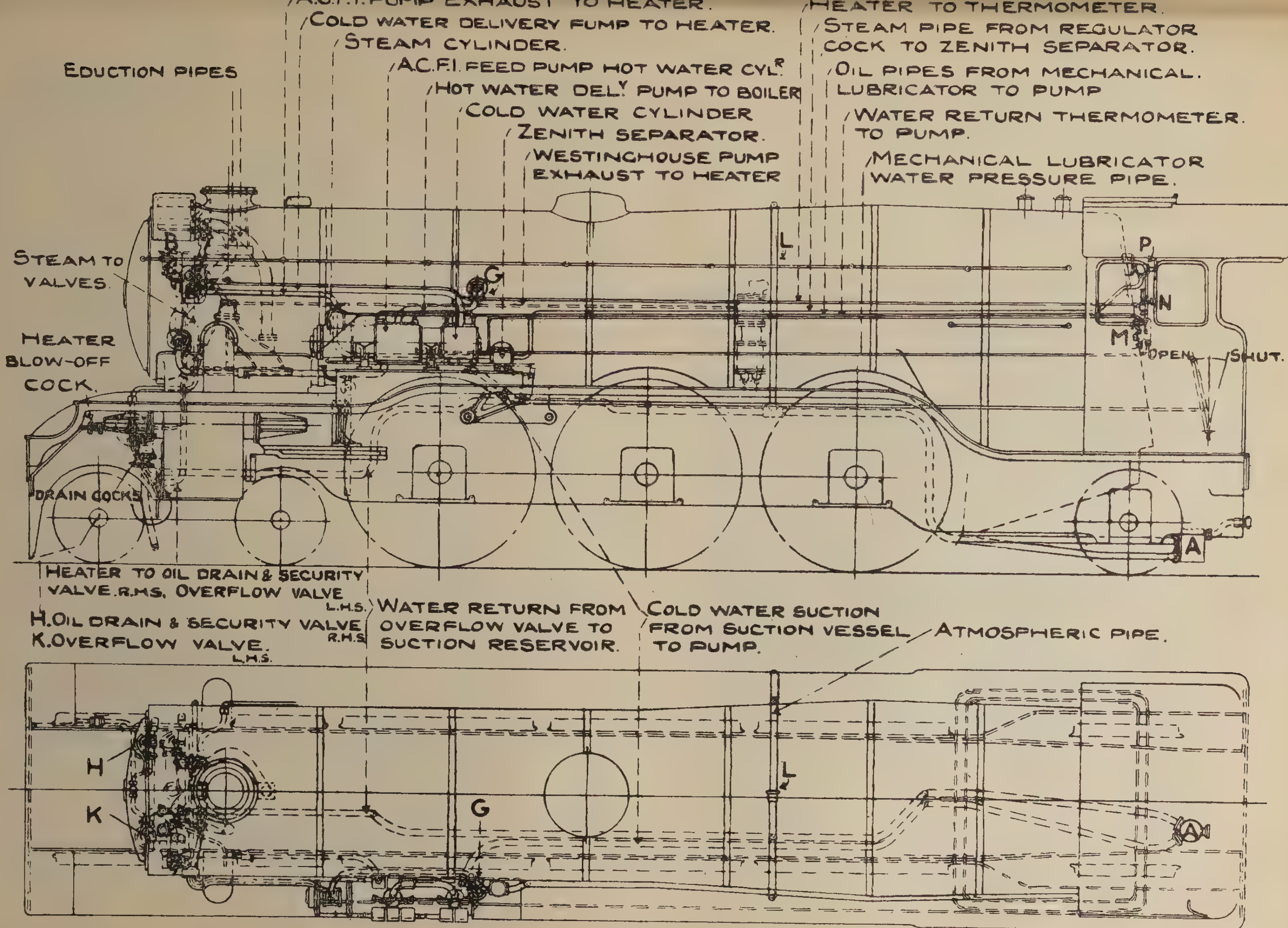
The oil drain and security valve « H », before mentioned, evacuates the separated oil from the oil separators « C. $C_1$. ». This valve also ensures the safety of the apparatus from the danger of the heater flooding, owing to the incrustation of the return pipe or a valve sticking on the pump.

The pump is arranged to deliver a greater quantity of cold water to the heater, than hot water to the boiler. It is to control this excess water plus the condensed steam that the return valve « K » is fitted. When water overflows into the level pipe « F » it flows to the underside of the valve, and when sufficient weight of water has collected it lifts the valve, and flows back to the suction vessel. On this return water pipe an atmospheric pipe « L » is fitted This atmospheric pipe, which is in the form of an inverted U tube, running over the boiler, prevents excess pressure being built up in the pipe system.

In practice, there is thus a constant circulation throughout the apparatus.

A mechanical lubricator « M » is fitted on the backplate of the boiler in the cab, worked by impulse from the pump to ensure a constant supply of oil to the pump, proportional to its speed. A manual lever is also fitted on the lubricator to flood the oil pipes at starting; this handle is also a useful indicator of the speed of working of the pump, as the handle lifts simultaneously with each stroke of the pump.

A thermometer « N » on the cab indicates the temperature at which the feed water is delivered to the boiler.


Cold water delivery pump to heater.
Steam cylinder.
A.C.F.I. feed pump hot water cyl$^{R}$.
Hot water del$^{Y}$ pump to boiler
Cold water cylinder
Zenith separator.
Westinghouse pump exhaust to heater
Heater to thermometer.
Steam pipe from regulator cock to Zenith separator.
Oil pipes from mechanical lubricator to pump
Water return thermometer. to pump.
Mechanical lubricator water pressure pipe.
Eduction pipes
Steam to valves.
Heater blow-off cock.
Drain cocks
Open
Shut.
Heater to oil drain & security valve R.H.S. overflow valve L.H.S.
H. Oil drain & security valve R.H.S.
K. Overflow valve. L.H.S.
Water return from overflow valve to suction reservoir.
Cold water suction from suction vessel to pump.
Atmospheric pipe.
A
G
L
M
N
P
H
K
Fig. 2.

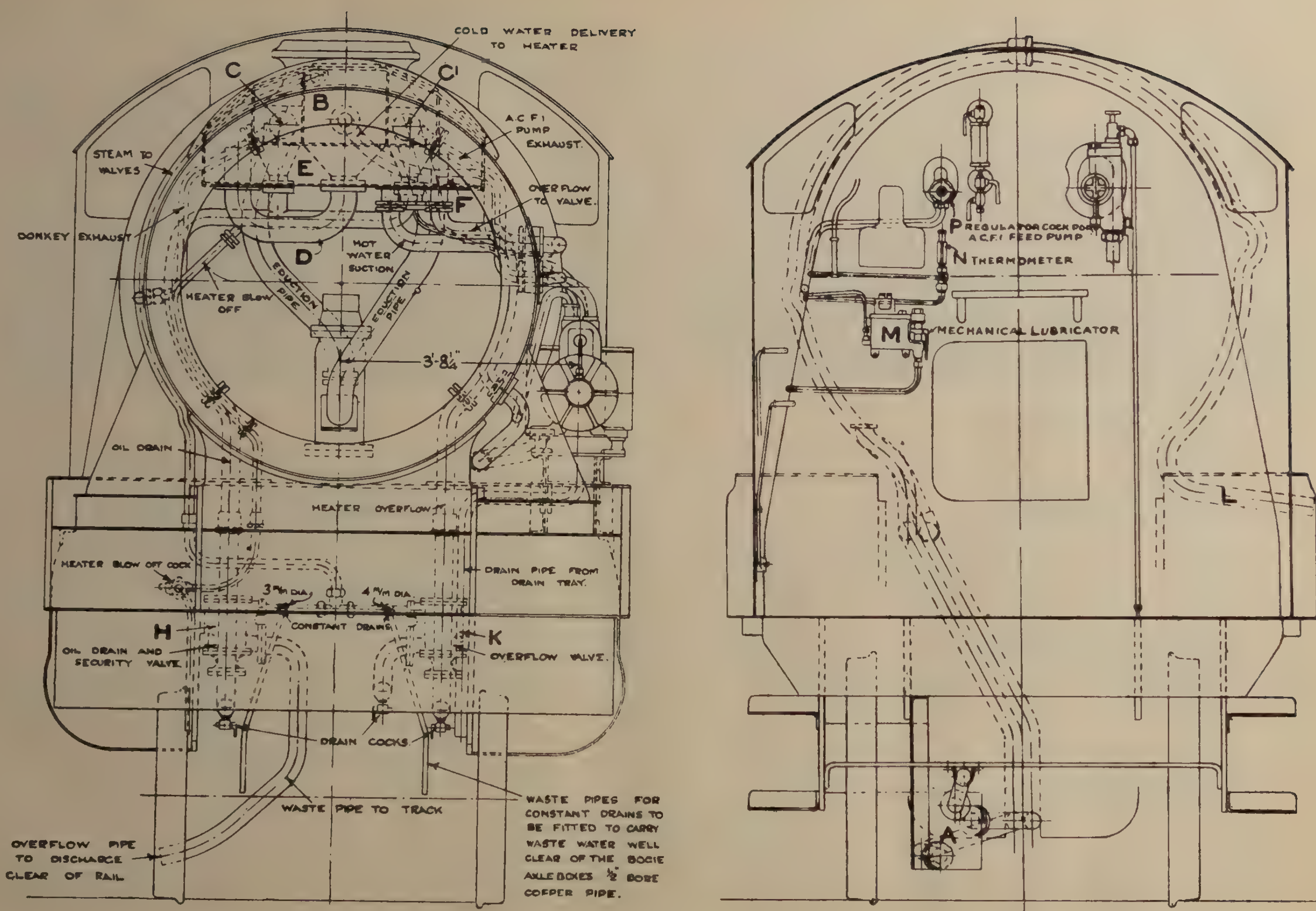

COLD WATER DELIVERY TO HEATER
C
C¹
B
A.C.F.I PUMP EXHAUST.
STEAM TO VALVES
E
OVERFLOW TO VALVE.
F
DONKEY EXHAUST
D
HOT WATER SUCTION
EDUCTION PIPE
EDUCTION PIPE
HEATER BLOW OFF
3'-8¼"
OIL DRAIN
HEATER OVERFLOW
HEATER BLOW OFF COCK
DRAIN PIPE FROM DRAIN TRAY.
3 M/M DIA.
4 M/M DIA.
CONSTANT DRAINS
H
K
OIL DRAIN AND SECURITY VALVE.
OVERFLOW VALVE.
DRAIN COCKS.
WASTE PIPE TO TRACK
WASTE PIPES FOR CONSTANT DRAINS TO BE FITTED TO CARRY WASTE WATER WELL CLEAR OF THE BOGIE AXLE BOXES ½" BORE COPPER PIPE.
OVERFLOW PIPE TO DISCHARGE CLEAR OF RAIL
P REGULATOR COCK FOR A.C.F.I FEED PUMP
N THERMOMETER
M
MECHANICAL LUBRICATOR
L
A

Fig. 3.

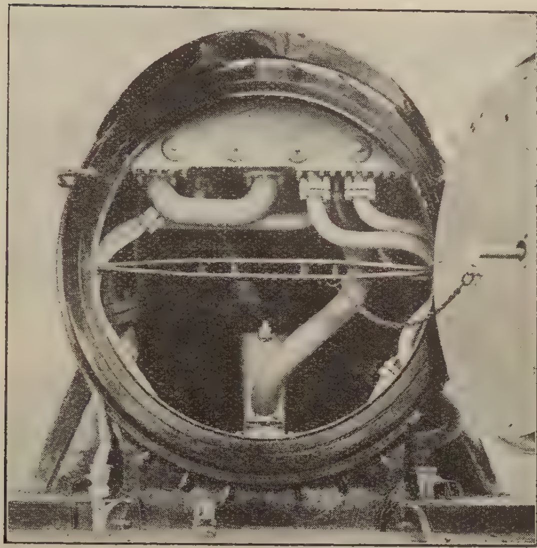


Fig. 4.

The speed of the pump is controlled by a steam regulator cock « P » conveniently fitted in the cab.

The apparatus is automatic in action; after the pump has been set to feed in proportion to the mean steam consumption of the locomotive, no further attention is required.

All pipe joints in the smokebox are of the lenticular self-adjusting type, and all hot water pipes are asbestos lagged. The pump is carried on a beam, which forms a well for the waste water from the cylinder water cocks of the pump. The beam is secured to the motion bracket at the front end, and to the quadrant lever bracket at the rear end.

Engine No. 2580 is fitted with a high pressure boiler, working at 220 lb. per square inch, while engine No. 2576 is pressed at 180 lb. per square inch.

[ 625. 245 (42) ]

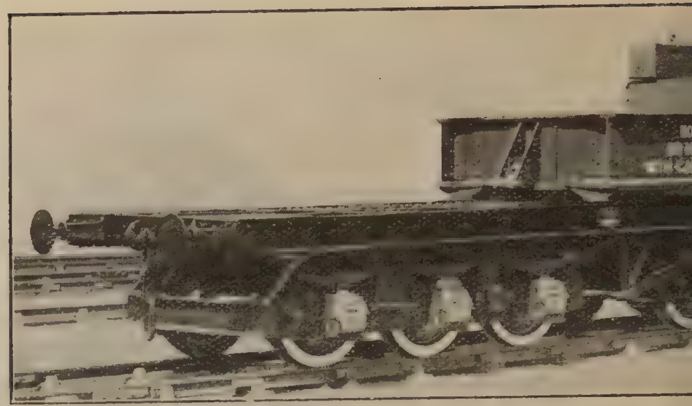
## Large capacity well trolley wagon.

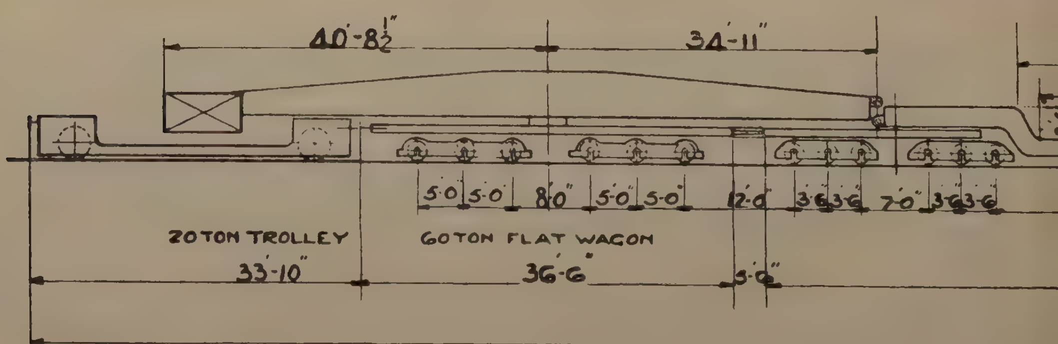
Figs. 1 to 5, pp. 3224 to 3226.

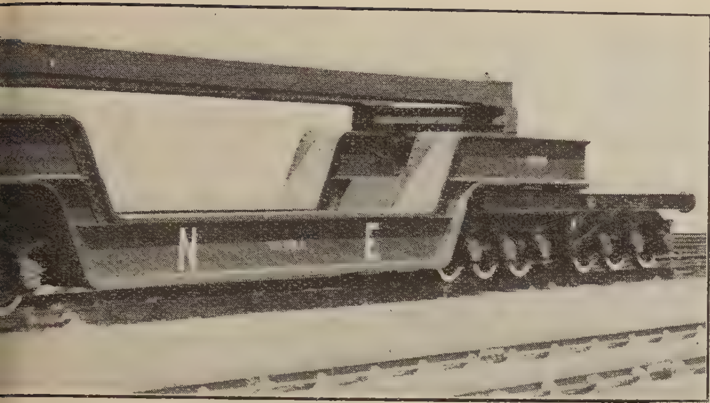
There has recently been constructed at the London & North Eastern Railway Locomotive Works, Darlington, to the designs of Mr. H. N. Gresley, C. B. E., Chief Mechanical Engineer to the Company, a well trolley wagon for conveying loads up to 110 tons in weight.

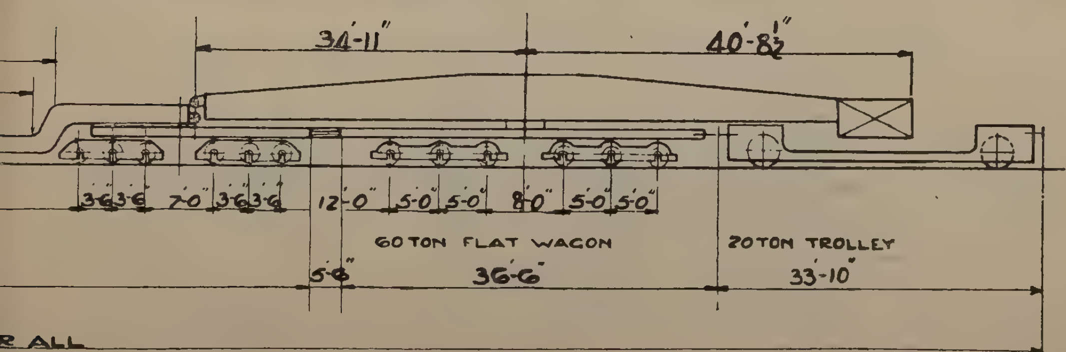
The wagon has been especially designed to accommodate heavy stators and other loads where the weight is concentrated in a comparatively small space.

As a unit the wagon is restricted to a maximum load af 110 tons to bring it within the limits of axle loads and spa-




40'-8½"
34'-11"
5·0 5·0 8'0" 5·0 5·0 12·0 3·6 3·6 7·0 3·6 3·6
20 TON TROLLEY
60 TON FLAT WAGON
33'-10"
36'-6"
5'-6"





34'-11"
40'-8½"
3'-6" 3'-6" 7'-0" 3'-6" 3'-6"
12'-0" 5'-0" 5'-0" 8'-0" 5'-0" 5'-0"
60 TON FLAT WAGON
20 TON TROLLEY
5'-6"
36'-6"
33'-10"

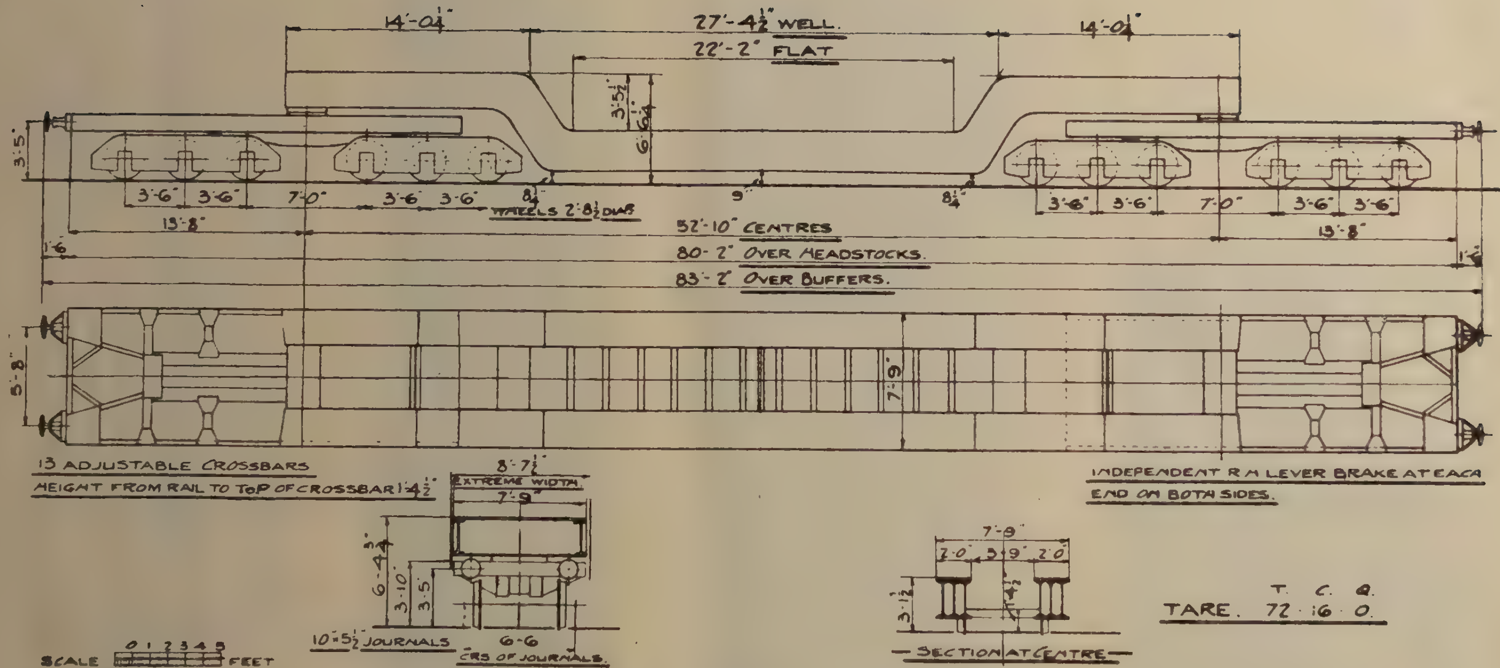



Fig. 5. — 110-ton trolley wagon.

cings allowed on the various railways.

The following are the principal dimensions :

| | |
|---|---|
| Length over buffers. . | 83 ft. 2 in. |
| Length over headstocks | 80 ft. 2 in. |
| Centre to centre of carrying trucks . . . . | 52 ft. 10 in. |
| Length of flat of main girders. . . . . . | 22 ft. 2 in. |
| Length of well . . . . | 27 ft. 4 1/2 in. |
| Length of wheelbase (extreme) . . . . | 74 ft. 2 in. |
| Height to top of main girders . . . . . | 3 ft. 1 1/2 in. |
| Height to top of adjustable cross girders . . | 1 ft. 4 1/2 in. |
| Width over main girders. . . . . . . | 7 ft. 9 in. |
| Width between main girders. . . . . . | 3 ft. 9 in. |
| Width (extreme). . . | 8 ft. 7 1/2 in. |
| Diameter of wheels on tread . . . . . . . | 2 ft. 8 1/2 in. |

The tare weight of the wagon is 72 t. 16 cwt.

The main superstructure comprises two girders each built up of three 24-inch rolled steel beams. Transverse adjustable crossbars are provided in the well in order to accommodate loads which require to be carried between the main girders.

Transverse and longitudinal timber beams for securing loads are also provided, the latter being adjustable.

The wagon is carried on four six-wheeled bogies.

This wagon has been designed to carry a maximum load of 150 tons, but as this load cannot be carried directly on the wheels, it has been necessary to relieve them of the surplus by means of the cantilever principle. Girders and balance weights have been provided, by means of which the surplus load of 40 tons is transferred to the two wagons adjacent to the load-carrying wagon.

When carrying a load of 150 tons the set will be made up as follows :

One 110-ton well trolley wagon;
Two 60-ton flat wagons, as pivots for the cantilevers;
Two 20-ton well trolley wagons, as under-runners for the balance weights,

arranged as shown in the diagram, and having an extreme length of 231 ft. 10 in. with a tare weight of approximately 220 tons.

The cantilever girders are connected to the main structure of the load-carrying wagon by fittings arranged in the nature of a universal joint, this being necessary in order that the set may accommodate itself to the various curves and elevations met with when running.

[621. 134.3 (42)]

# „R. C." Poppet valve gear

## as applied to London and North Eastern Railway 3-cylinder, 4-4-0 type engines, Class „D. 49."

Figs. 1 to 4, pp. 3228 to 3232.

Two 4-4-0 type 3-cylinder express passenger locomotives Nos. 336 and 352 have recently been fitted with a rotary cam poppet valve gear supplied by Messrs. Lentz Patents Ltd. This arrangement is known as the « R. C. » poppet valve gear, and consists of a camshaft which obtains a rotary motion by means


Fig. 1. — General view.

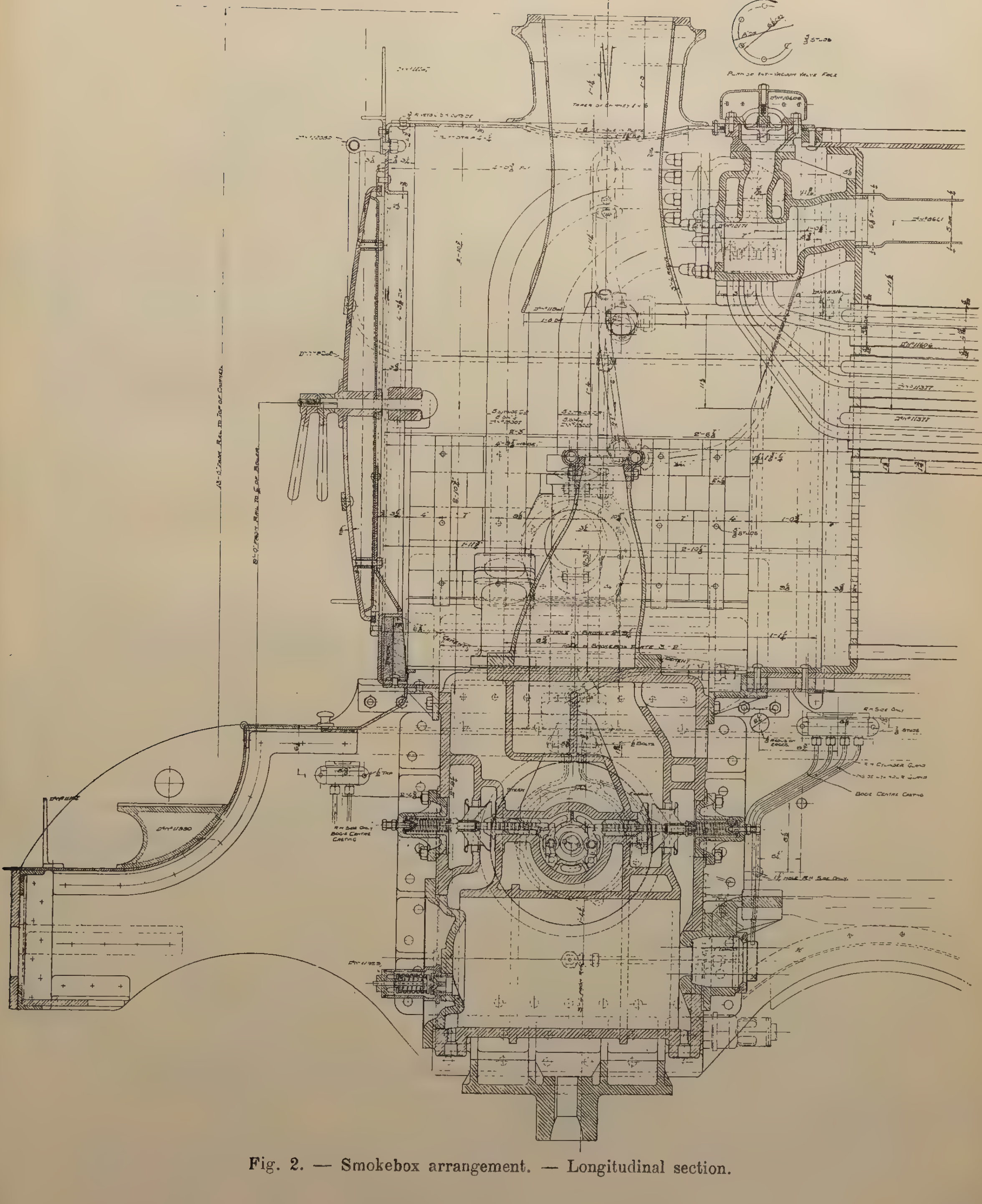


Fig. 2. — Smokebox arrangement. — Longitudinal section.

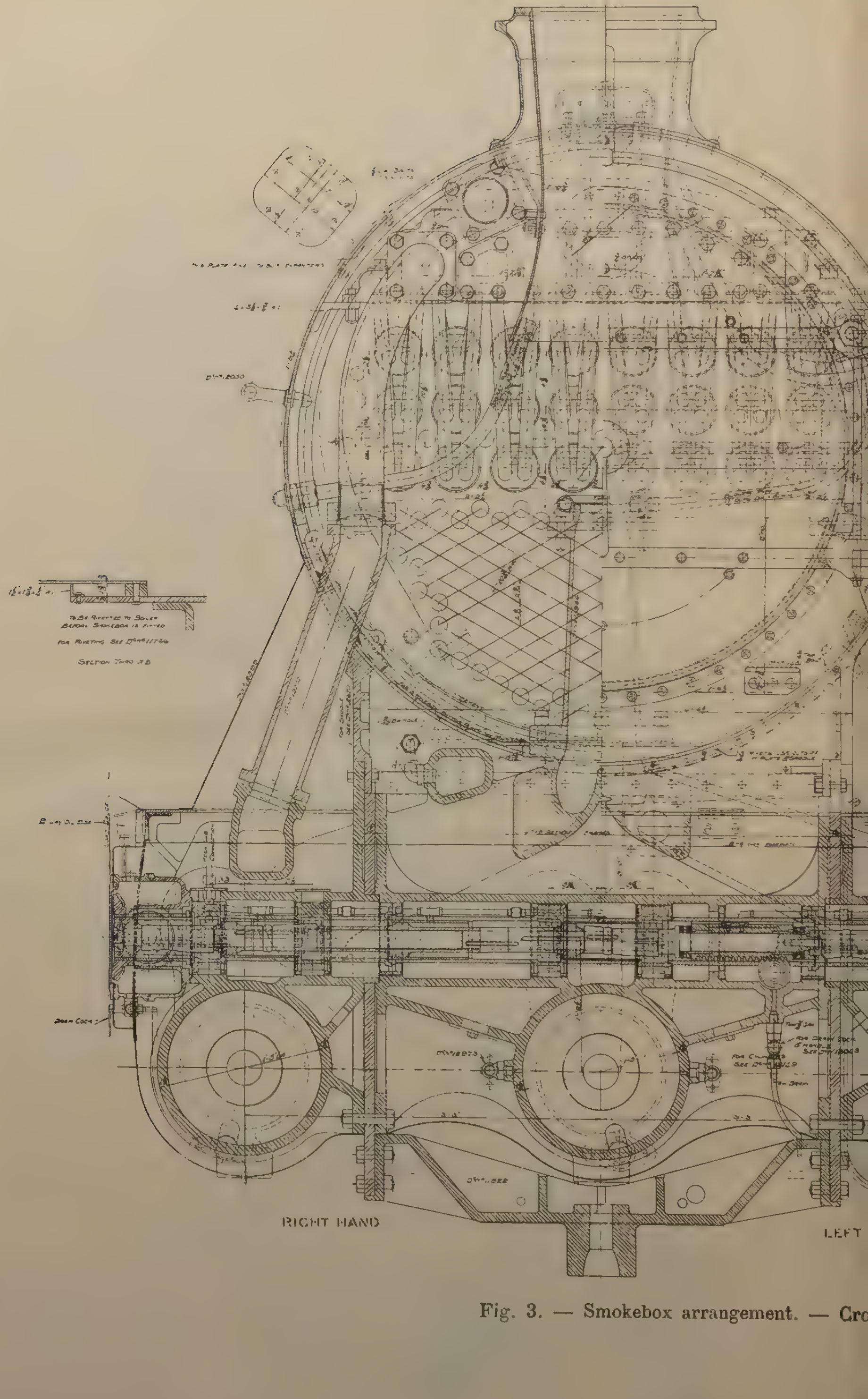
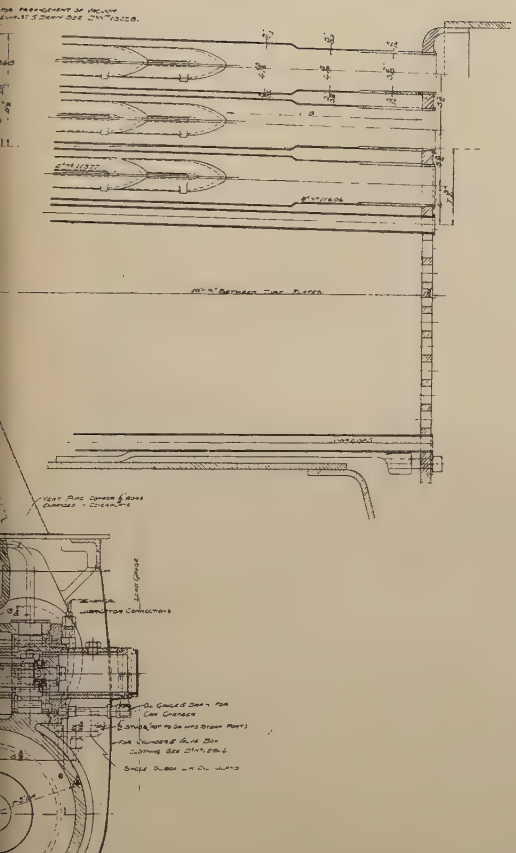



Fig. 3. — Smokebox arrangement. — Cro



of suitable gears and shafting so arranged that the rotation of the camshaft can be synchronised with that of one of the coupled axles.

As applied to the locomotives in question the camshaft is placed above the cylinders with its axis at right angles to the horizontal centre line of the locomotive. It is made of high tensile steel and has mounted on it specially formed stepped cams arranged to control the steam admission and exhaust valves for each of the three cylinders.

The steam inlet cams for each cylinder are made in two separate sections; those for forward gear running provide for five different rates of admission ranging from a minimum cut off of 15 % to a maximum of 75 % in full gear; whilst for back gear running a further set of cams are used which give two rates of admission; one for full gear and the other giving a shorter rate of cut off of 35 %.

In addition there is provided a cylindrical cam for each cylinder for the purpose of closing the steam valves when the engine is placed in « mid gear », when in which position the exhaust valves are held open by a similar cam of larger diameter in the exhaust set.

The arrangement of the exhaust cams is somewhat similar but only three different profiles are provided. They are designed in such a way that when the engine is in full gear the point of compression starts later than is the case at the shorter admission rates. This arrangement permits of the ready exhaustion of the steam and assists in starting. Separate exhaust cams also enable the point of release to be adjusted to suit the cut-off and in this instance release takes place at 90 % in full gear and 80 % for all other cut-offs.

The arrangement of the valves is entirely similar to that employed with the oscillating cam type of gear which utilizes a link motion as commonly found

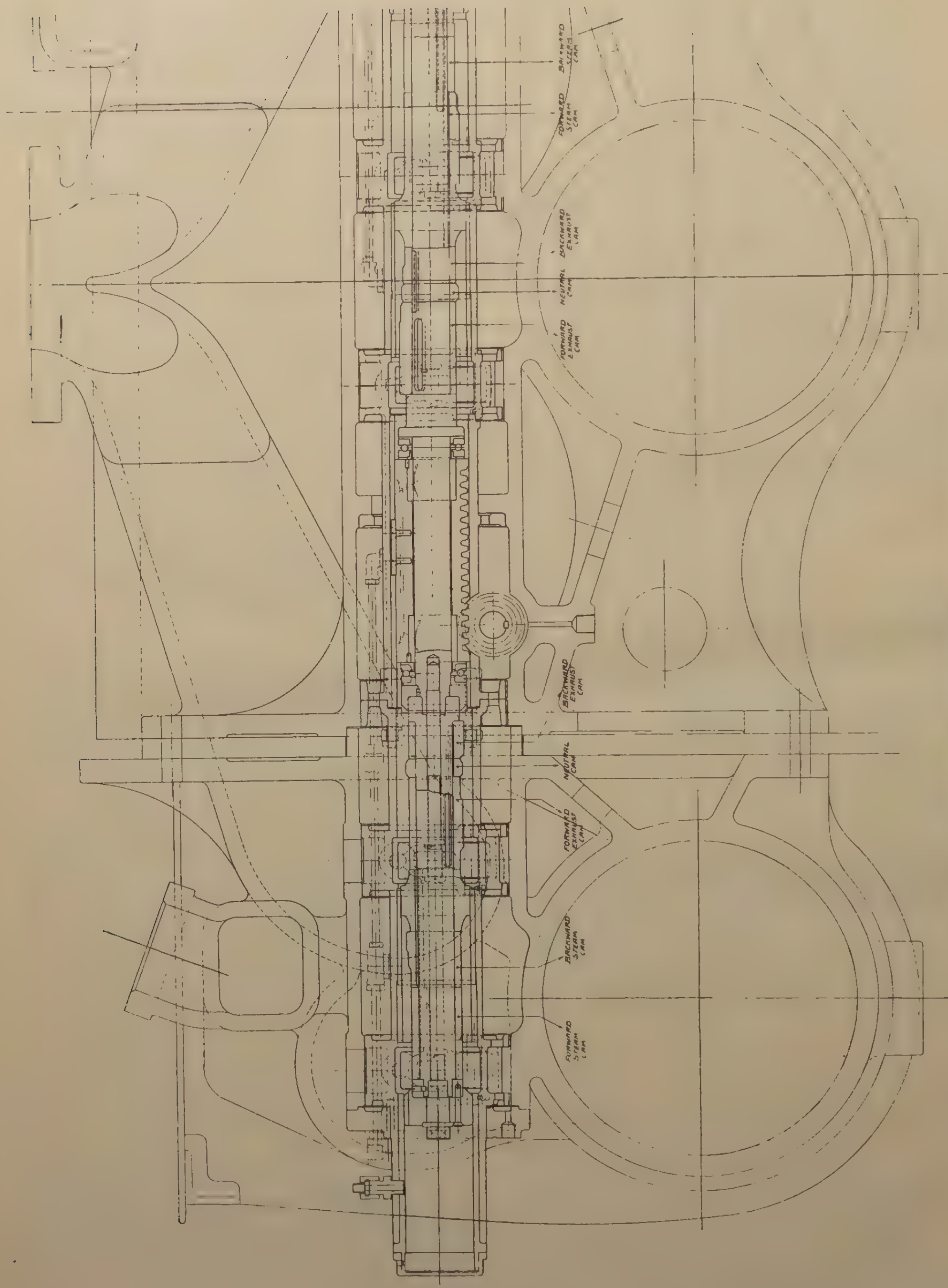



Fig. 4. — Sectional arrangement through cam chamber.

in locomotives. They are placed with their axis in the horizontal plane, a position which lends itself to locomotive requirements, and is peculiarly adapted for engines having inside cylinders. At the same time the valves are easily accessible. There are four valves for each cylinder, two for admission and two for exhaust.

Disposed between the cams and the valve splindles there are intermediate levers which are fitted with specially shaped rollers which bear against the cam profile. This arrangement permits of the valve spindles being made as light as possible, an important feature in a gear of this description, and at the same time permits of the use of comparatively large port openings for any given cam profile.

The intermediate levers are pivoted on fulcrum pins which are carried in a circular cast iron cage which is also provided with suitable bushings for the bearings supporting the cam shaft. The caging fits into an annular cavity extending for the whole width of the cylinder castings.

The method employed to impart the required rotary motion to the cam shaft is as follows :

At one end of the cam shaft is securely keyed a driving dog which is fitted in a hollow sleeve in the bore of which are cut suitable key ways engaging with appropriate projections formed solid with the driving dog.

At one end of the sleeve and on its outer periphery is keyed a spiral bevel wheel.

The object of this arrangement is to permit of the rotation of the camshaft by means of the driving dog and at the same time allow the shaft to be moved in an axial direction for the purpose of reversing as will be explained later.

The spiral bevel keyed to the driving sleeve engages in turn with another bevel wheel keyed to a shaft carried in a suitable bearing which is formed in the gear casing.

Extending backwards outside the locomotive is another length of shaft which is carried by a bearing bracket fitted with ball bearings and fixed to the right hand outside cylinder slide bar bracket From this point there is another length of shafting fitted at each end with standard Hardy-Spencer universal joints, a fixed joint being used at the motion bracket and at the end next the main-driving gear box a slip joint is provided.

The main driving gear box itself consists of two spiral gears mounted in a dust proof oil tight casing. The main driving wheel is keyed to a return crank arranged so that the axis of the pin corresponds with the axis of the main driving axle.

The gear box is fitted with ball bearings throughout and held in position by means of an anchor link secured to the top of the casing and to a bracket attached to the side footplating.

The reversing gear consists of the usual type of hand wheel fixed in the cab, the spindle of which is coupled to a shaft which runs along the boiler carried on suitable brackets to a bevel gear box and from thence by a shaft which extends downwards to a selflocking gear box fitted to the inside of the main frame and which contains a pair of spiral gears.

From thence a short shaft passes into the cylinder casting on the end of which is keyed a pinion gearing with a rack running on the camshaft. It is thus possible by rotating the hand gear in the cab to move the camshaft transversely relative to the locomotive centre line, and thus bring any cam at will into contact with the rollers on the intermediate levers.

In that manner any cut off provided by the cams may be employed, or alternatively the engine may be reversed.

Further on the gear being put into its «mid» position the steam valves are closed and the exhaust valves being held off their seats, an adequate bye-pass is provided.

It must be understood that when in this position no movement of any kind is imparted to the valves or intermediate lever equipment.

Lubrication of the camshaft and valve spindles is provided for by means of a mechanical lubricator with suitable connections to the camshaft bearings and also to the valve spindle bushes. In order to ensure a proper supply of oil of the right consistency for these parts an anti-carboniser attachment is provided.

So far as the poppet valves themselves are concerned it is interesting to observe that these remain perfectly steam tight over extended periods of time and that tests have shown that when the engine is placed in mid-gear, in which position the steam valves are closed, no steam whatever escapes from the cylinder cocks when the regulator is opened wide and with steam at its full working pressure.

As a further point of interest it may be noted that in the case of the engines under consideration the weight at the front end, that is over the bogie, is lower by approximately 1 1/2 tons as against the same type of engines fitted with piston valve cylinders. This is largely due to the suppression of the valve gear details and other parts incidental to its use.

# OBITUARY.

## HIPPOLYTE VANDERRYDT,

Honorary Professor at the University of Brussels,
Honorary Administrator of the Belgian State Railways,
Former Member of the Permanent Commission of the International Railway Congress Association.

An eminent Railway Engineer, Mr. Hippolyte VANDERRYDT, whose amiability of character had made him a large circle of friends, died recently at Brussels.

Mr. Vanderrydt entered the Railway Administration immediately after leaving the Technical School of the University of Liége.

He very soon made his mark as the prime mover in the introduction of facilities intended to improve the comfort of the enginemen and by the improvements he made in the equipment of the depots. His organising talent resulted after the War in his being given charge of the preliminary investigations into the industrialisation of the Railways. He sat on several Commissions considering the modifications of the legal regime of the Railways and largely contributed to the work done by them.

When made responsible for the Rolling Stock and Locomotive Running Department, he drew up the scheme of reorganisation of the locomotive depots, and imparted the necessary energy to his subordinates to ensure his ideas being carried out. Under his control the education of the enginemen was reorganised and the necessary and improved equipment for this purpose was made available.

Mr. Vanderrydt was also well known as an economist, as a social reformer, and as a publicist. He contributed to the daily press many articles dealing with technical matters in a simple manner for the benefit of the manual workers.

Mr. Vanderrydt always took the greatest interest in the work of this Association.

In May 1914 he was nominated Assistant Secretary of the Editorial Committee of the *Monthly Bulletin*, and from December 1919, until July 1922, he was its Secretary.

At the final meeting of the Rome Session in 1922, he was nominated a Member of the Permanent Commission, and retained this appointment until February 1925, at which date he ceased to belong to the active Staff of the Administration of the Belgian State Railways.

He published in collaboration with Mr. Ed. MINSART, a « Course of Railway Operation » in 2 volumes, a review of which was published in the *Bulletin* (1).

We present to his widow and to his family our most sincere sympathies in their loss.

*The Executive Committee.*

(1) See *Bulletin of the Railway Congress*, March 1924 number, p. 243.

# NEW BOOKS AND PUBLICATIONS.

[621 .131 & 621. 135]

CORINI (Felice), Engineer, Professor at the Royal School of Engineers of Bologna. — **Meccanica della locomozione** (**The mechanics of locomotion**), 2nd edition. — One volume (9 5/8×7 inches) of 324 pages with 175 figures and 6 plates. — 1929, Turin, Unione Tipografico, Editrice Torinese, 28, Corso Raffaelo.

This book is the first volume of a treatise which consists in all of five and which has for title : *Construction and Operation of Railways.*

Its object is the study of the problems of mechanics which arise in connection with the movement of railway vehicles over the line.

The author has divided it up into four chapters entitled :

Chapter I. — Tractive resistance.
» II. — Traction.
» III. — The movement of vehicles through curves.
Chapter IV. — Abnormal movements of rolling stock.

The *tractive resistance* consists of various resistances which are analysed in turn; axle friction, rolling friction of the wheels on the rails, resistance due to the profile of the tyres, resistance of the air, and resistance due to irregularities in the track. As regards rolling friction, by making certain hypotheses upon the distribution of the pressures we get Coriolis' formula which contains the weight of the wheels with the exponent 4/3. The author gives a formula in which the weight P is included with the exponent 5/3.

After these theoretical investigations the formulae by known authors are given and translated into diagrams.

The investigation into the resistance on curves is of value in that it contains an analysis of the various frictions which develop while running through the curve.

The inertia resistance which is equal to the force required to develop a given acceleration is increased from the fact that there are revolving parts the energy of rotation of which is added to the inertia of translation. The author gives the formula to be used with permissible approximations as well as the formula applicable to the case in which the parts revolve at a different speed from that of the wheels.

In chapter II entitled *Traction* the author considers first of all the problem of adhesion, then that of traction by means of propellers and compares the two systems from the points of view of efficiency, this term designating the ratio of the work corresponding to the distance travelled by the weight hauled to the corresponding work done in moving the total weight of the train. He concludes that the propeller might give good results in the case of light trains running at high speeds.

The author then gives the general equation for the movement of translation of a train on the straight and on curves, in the case of adhesion traction and in the case of traction by propeller, passing to the idea of the limiting gradients and to that of the maximum acceleration. He studies analytically and graphically the period of variable movement which lies between the instant of starting and that at which the working speed is reached. In the same way the question of braking is analysed according to various methods taking into account the factors affecting it : gradient, speed, number and kind of the brakes and using the equations put forward to represent the variation in the coefficient of friction. In addition problems relating to traction by means of propellers are dealt with.

In a paragraph entitled : Power of the

locomotive and Energy diagram, the author studies the question of the adhesive weight, that of the specific power and of the power absorbed at any moment during the running of a train. This leads him to examine the instruments employed for dynamometric purposes on the railways. He gives a description with the complete theory of these apparatus amongst which will be noticed the Doyen inertia ergometer, together with a detailed description of the test methods in use and of the diagrams recorded and prepared by these methods.

Chapter III, *Movement of vehicles on curves,* starts by an investigation into the conditions of equilibrium of a vehicle running at a determined speed through a curve of given radius.

The question of superelevation of the track and the connection of the straight line to the line on curves, are then considered. The author gives the equations for the transition curves, exact and approximate curves, gives the methods in use for laying out the curves and numerical tables of the coordinates.

A special paragraph is devoted to the study of the inscription of vehicles on curves, taking into account the effect of friction by methods now become classic.

Chapter IV, *Abnormal movements of rolling stock* consists of a first part relating to conditions of stability considered from the general point of view. The author takes the equation of the movement of the spring borne part and studies the action of forces and of couples of various directions. He examines the influence upon the stability of equalising levers.

A second part contains the study of the abnormal movements due to the rolling stock itself, movements due to the steam action and to that of parts in movement, both for steam locomotives as for electric locomotives, and the study of the movement due to irregularities of the track in the horizontal and in the vertical plane.

A very interesting paragraph is that dealing with the gyroscopic effect upon railway vehicles, an action which shows itself whilst running through curves and while running through the transition curves. It is followed by another in which are studied aperiodic spring systems.

A last paragraph deals with the methods and instruments used to measure abnormal movements.

This book of a definitely scientific character of which we have only been able to give a very incomplete idea has the great merit of stating in a very clear manner many questions which are often dealt with in papers where simplicity is sought after rather than exactitude. It will certainly be much appreciated by those who are endeavouring to elucidate by means of theoretical investigation based upon experimental results the numerous problems still without completely satisfactory solutions and which become of great importance as the speeds increase and as new types of rolling stock are introduced.

E. M.

# ANALYTICAL TABLE OF ARTICLES

## ARRANGED ACCORDING TO THE DECIMAL CLASSIFICATION

## (1929)

# 623. Military and naval engineering.

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# 624. Bridges and roofs.

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| Estudio y construccion de tramos-metalicos (Design and construction of metal bridges), by Domingo MENDIZABAL. (New book) | October. | 239 |

### 624. 2. Girders. Stresses and strains.

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|---|---|---|
| Dynamic stresses and vibrations of the main girders of railway bridges | January. | 10 |
| Investigation into the static and dynamic stresses in railway bridges (subject III, IIth session) : | | |
| Report No. 1 (America), by P. G. LANG, Jr. | May. | 50 |
| Report No. 2 (British Empire, China and Japan), by Sir Henry FOWLER and G. ELLSON | July. | 85 |
| Report No. 3 (Belgium, France and their Colonies), by Messrs. A. A. C. RONSSE and R. DESPRETS | December. | 310 |
| Report No. 4 (all countries except America, the British Empire, China, Japan, Belgium, France and their Colonies), by A. FAVA | " | 312 |

### 624 .6 Arched bridges.

#### 624 .62. Metallic.

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| The projected Kill van Kull steel arch bridge between New Jersey and Staten Island, New York City | June. | 57 |

#### 624. 63. Reinforced concrete.

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| The use of concrete and reinforced concrete on railways (subject I, 11th session) : | | |
| Report No. 1 (Belgium, France, Italy, Portugal, Spain and their Colonies and Switzerland, by Messrs. JULLIEN and CLAISE | October. | 195 |
| Report No. 2 (America, British Empire, China and Japan), by F. B. FREEMAN. | May | 43 |
| Report No. 3 (all countries, except America, the British Empire, China, Japan, Belgium, France, Italy, Portugal, Spain and their Colonies and Switzerland), by E. KRICK. | December. | 297 |

### 624 .7. Composite bridges.

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| The calculation of ferro-concrete bridges consisting of three spans supported on fixed piers, by F. BERGER and P. VAN WEYENBERGHE | January. | |

# 625. Railway and road engineering.

### 625 .1. Way and works.

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| The transpyrenean railways, by M. GARAU | April. | 37 |
| The Franco-Italian Railway from Nice to Coni, via Sospel, by G. BLOT | June. | 77 |

# 651. Office equipment and methods.

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| Use in railway work of machines for simplifying statistical and accountancy work (subject XIV, 11th session) : | |
| Report N° 1 (America, British Empire, China and Japan), by W. E. EPPLER. . . | May. |
| Report N° 2 (all countries, except America, British Empire, China and Japan), by Messrs BRUNEAU and BOISTEL d'WELLES . . . . . . . . . . . . . . | November. |

# 652. Writing. Materials, typewriters, cipher.

| | Month. |
|---|---|
| Use in railway work of machines for simplifying statistical and accountancy work (subject XIV, 11th session) : | |
| Report No. 1 (America, British Empire, China and Japan), by W. E. EPPLER . | May. |
| Report No. 2 (all countries, except America, British Empire, China and Japan), by Messrs. BRUNEAU and BOISTEL d'WELLES . . . . . . . . . . | November. |

# 655. Printing. Publishing. Copyright.

| | Month. |
|---|---|
| La Federazione internazionale della stampa tecnica e il suo IV° Congresso. (The International Technical Press Federation and its IVth Congress), by A. STABARIN (New book) . . . . . . . . . . . . . . . . . . . . . . | September. |

# 656. Transportation. Railroading, etc.

| | Month. |
|---|---|
| Cours d'exploitation de chemins de fer. Tome I. Exploitation commerciale. 2e édition (Railway operating course, Vol. 1, Commercial operating, 2nd edition), by U. LAMALLE (New book) . . . . . . . . . . . . . . . . . . . . | June. |

## 656.1. Carriage by road.

| | Month. |
|---|---|
| Road and rail transport . . . . . . . . . . . . . . . . . . . . . | January. |
| Great Western Railway makes agreement with road undertaking . . . . . . . | April. |
| An agreement between the London Midland & Scottish, London & North Eastern Railways and the Sheffield Corporation . . . . . . . . . . . . . . . . . . | " |
| Competition of road transport (subject XIII, 11th session) : | |
| Report No. 1 (America, China and Japan), by C. B. SUDBOROUGH. . . . . | June. |
| Report No. 2 (Belgium, France, Italy, Portugal, Spain and their Colonies), by Messrs. LE BESNERAIS and DEGARDIN . . . . . . . . . . . . . | November. |
| Report No. 3 (British Empire), by H. L. WILKINSON . . . . . . . . | August. |
| Report No. 4 (all countries, except [illegible]erica, the British Empire, China, Japan Belgium, France, Italy, Portug[illegible] [illegible]n and their Colonies), by A. WASIUTYNSKI . . . . . . . . . . . . . . . . . . . . . | December. |

## 656.2. Carriage by railway.

| | Month. |
|---|---|
| Road and rail transport . . . . . . . . . . . . . . . . . . . . . | January. |
| Great Western Railway makes agreement with road undertaking . . . . . . | April. |
| An agreement between the London Midland and Scottish, London and North Eastern Railways and the Sheffield Corporation . . . . . . . . . . . . . . . | " |
| Handling London's Underground traffic, by J. B. THOMAS. (New book) . . . . | June. |
| Competition of road transport (subject XIII, 11th session) : | |
| Report N° 1 (America, China and Japan), by C. B. SUDBOROUGH . . . . . | " |

| | Month. | Pages. |
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| **656 .253. Fixed and station signals. Fog signals.** | | |
| Automatic train control systems on the Railways of the United States, by A. KAMMERER | March. | 291 |
| Automatic train control in Germany | August. | 1529 |
| **656 .254. Apparatus for communicating information at long distances. Alarm bells and special warnings Telegraph. Telephone. Communication between stations and trains in motion Various systems of working. Train dispatchers. Covering break-downs.** | | |
| Highway crossing protection | May. | 551 |
| Note on the organisation of duties in the Central Train Control Offices on the French Eastern Railway | June | 821 |
| The new Swiss regulations relating to the gates and signalling of level crossings, by H. HUNZIKER | December. | 2837 |
| **656 .259. Other safety measures. (Inter-communication and inter-communicating apparatus on trains Speed recorders situated on trains or on the line, treadles).** | | |
| Periscopes on electric trains, Southern Railway, Great Britain | June. | 841 |
| Passenger communication on the new stock of the Italian State Railways | August. | 1541 |
| **656 .26 Accessory services** | | |
| **656 .261. Collection and delivery.** | | |
| The use of containers on British Railways | July. | 1146 |
| **669. Metallurgy and assaying.** | | |
| International Mining, Metallurgy and Applied Geology Congress | September. | 1955 |
| **669 .1. Iron and steel.** | | |
| The relative values of the tests employed during the inspection of steel for manufacturing purposes, by Ch. FRÉMONT | February | 168 |
| Strain effects in mild steel by H. S. RAWDON | " | 175 |
| Special hard wearing steels for use in points and crossings, by P. MARTHOUREY | March | 232 |
| The relative values of the tests employed during the inspection of steel for manufacturing purposes, by R. GRANJON | May. | 548 |
| **721 .9. Iron and composite structures.** | | |
| The use of concrete and reinforced concrete on railways (subject I, 11th session) : | | |
| Report No. 1 (Belgium, France, Italy, Portugal, Spain and their Colonies and Switzerland), by Messrs JULLIEN and CLAISE | October. | 1959 |
| Report No 2 (America, British Empire, China and Japan), by F B. FREEMAN | May. | 433 |
| Report No. 3 (all countries, except America, the British Empire, China, Japan, Belgium, France, Italy, Portugal, Spain and their Colonies and Switzerland), by E. KRICK | December. | 2975 |
| **725 .33. Railway shops, round houses, car houses, water supply and storage, stores.** | | |
| Water softening for locomotive boilers. London & North Eastern Railway installs new plant at Annesley | April. | 413 |

# MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

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**P. GHILAIN,**

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(SEPTEMBER 1929)

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## I. — BOOKS.

### In French.

1929 62. (01

ARAGON (E.), Ingénieur.

**Résistance des matériaux** appliquée aux constructions. (Méthodes pratiques par le calcul et la statique graphique.)

Paris (VIe), Dunod, 92, rue Bonaparte, un volume (12 × 18 cm.), VIII, 718 pages avec 377 figures. (Prix : 65 francs.)

1929 62. (01

CHÉVENARD (P.), Ingénieur.

**Analyse dilatométrique des matériaux.**

Paris (VIe), Dunod, 92, rue Bonaparte, un volume (21 × 27 cm.) de VIII, 80 pages, 28 figures et 6 planches. (Prix : 35 francs.)

1929 385 .3 (.44)

de la RUELLE (J.), Avocat.

**Contrôle** des chemins de fer et des tramways.

Paris (VIe), Dunod, 92, rue Bonaparte, un volume (12 × 18 cm.), 554 pages. (Prix : fr. 6.75.)

1929 621 .43

ECORCHON (F.), Ingénieur.

Le **moteur Diesel** et ses dérivés. Moteurs à boule chaude et moteurs à précombustion.

Paris (Ve), Delagrave, 15, rue Soufflot, un volume (16.5 × 25 cm.), 533 pages et 374 figures. (Prix : 90 francs.)

1929 385. (01 (.6)

FOCK (A.), Ingénieur.

Le **chemin de fer transsaharien.** — Tracé, construction et exploitation.

Paris (VIe), Société d'éditions géographiques, maritimes et coloniales, 184, boulevard Saint-Germain, un volume in-8° broché, avec une grande carte en couleurs du Sahara au 4.000.000e. (Prix : 40 francs.)

1929 621 .4

LAMY (R.), Ingénieur.

Réglage et essais des **moteurs à explosion.**

Paris (VIe), Dunod, 92, rue Bonaparte, un volume (16 × 25 cm.), IV, 308 pages et 158 figures. (Prix : 74 francs.)

1929 744. (02

MORISE (Numa).

**Manuel du dessinateur industriel.** — Principes géométriques et applications, tracés et calculs.

Paris, J. B. Baillière et fils, un volume in-16, de 608 pages, avec 110 figures. (Prix : 30 francs.)

1929 62. (08

TURBAT (P.).

**Barèmes pour le calcul des poutres, solives, linteaux, portails, chevrons, etc., à la portée de tous, sans formules algébriques, par simple multiplication.**

Paris (VIe), Dunod, 92, rue Bonaparte, un volume (16 × 25 cm.) de 54 pages. (Prix : 17 francs.)

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1929 621. (02

DUBBEL (H.).

**Taschenbuch für den Maschinenbau.**

Berlin, Julius Springer, 1 756 Seiten mit 2 800 Text-Abb., in 2 Bänden. (Preis Geb. : 26 Rm.)

1929 69. (02

FRICK (Otto) & KNOLL (Karl).

**Baukonstruktionslehre.** Leitfaden für den Unterricht an Baugewerkschulen und verwandten technischen Lehranstalten. Erster Teil : Elfte Auflage. — Zweiter Teil : Zehnte neubearbeitete Auflage.

Leipzig und Berlin, Verlag von B. G. Teubner. Erster Teil : VIII-166 Seiten mit 298 Abb. im Text. (Preis : 3.60 Rm.). Zweiter Teil : VII-202 Seiten, mit 287 Abb. im Text. (Preis : 4.60 Rm.)

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International. of Brussels. (See « Bibliographical Decimal Classification as applied to Railway Science », by L. WEISSENBRUCH in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509).

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**Dampfturbinen.** Berechnung und Konstruktion.

München und Berlin, R. Oldenbourg, 103 Seiten in gr. 8°, mit 61 Abb. (Preis : 6 Rm.)

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1929 656 .25 (06 (08 (.73)

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**Proceedings Signal Section.** Advance notive. Eighty-fourth stated meeting, Atlanta, Ga., September 10, 11, 12, 1929.

New York. Published by the Association, 30, Vesey Street.

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The care and operation of **machine tools.**

New York, John Wiley & Sons, 292 pages, illustrated, (6 × 9 inches). (Price : $2.75.)

1929 621 .33

BURTT (Philip).

**Railway electrification** and **traffic problems.**

London and New York, Sir I. Pitman & Sons, 197 pages. (Price : 10 sh.)

1929 385. (02 (.42)

**How to send and how to save.**

London, Great Western Railway. (5 1/2 × 8 1/2 inches), 100 pages, with folding map.

1929 385. (02 (.54)

INDIAN STATE RAILWAYS.

**General rules for all open lines** of railways in British India administered by the Government. Part I, II, III.

Simla, Government of India Press.

1929 656 .256 (.5

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Principles of the **absolute block system.**

Madras, printed for the Railway Board at the Madr & Southern Mahratta Railway Press, Rayapuram.

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Photomicrographs of **iron** and **steel.**

New York, John Wiley & Sons, 253 pages. (Pric $5.00.)

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Canton (Ohio), published by Timken Roller Beari Company, 27 pages.

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**Accounting** by **machine methods.**

New York, Ronald Press, 556 pages. (Price : $7.5

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London. Published by the London & North Easte Railway, 128 pages. (Price : 1 sh.)

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WALCKER (Reginald David), M. C.

The principles of **underdrainage.**

London, W. C. 2, Chapman & Hall Limited, 11, H rietta Street. (5 1/2 × 8 3/4 inches), 223 pages. (Pri 15 sh. net.)

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#### Arts et Métiers. (Paris.)

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LACASSE (J.). — **La combustion du charbon pulvérisé.** (5 700 mots & fig.)

1929 625 .214

Arts et Métiers, juillet, p. 261.

DAMIEN (M.). — **Considérations pratiques sur les divers systèmes de boîtes d'essieux du matériel roulant des chemins de fer.** (3 900 mots & fig.)

#### Bulletin de l'Union internationale des chemins de fer. (Paris.)

1929 385. (09 (.4

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**Le réseau Paris-Lyon-Méditerranée de 1924 à 19** — Extrait du rapport présenté par le Conseil d'adr nistration à l'Assemblée générale des actionnaires 25 avril 1929. (A suivre.) (7 000 mots.)

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**Les chemins de fer exploités par l'Etat tchécoslovac** pendant les exercices 1925, 1926 et 1927. (13 300 mot

## Bulletin des transports internationaux par chemins de fer. (Berne.)

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ıll. des transp. intern. par ch. de fer, juillet, p. 349.

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1929 691

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HALCROW (W. T.), BROOK (G. B.) & PRESTON ʀ.). — L'action corrosive des eaux tourbeuses sur les tons. (A suivre.) (2 900 mots, 10 tableaux & fig.)

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— n° 2449, 20 juillet, p. 63.

DANTIN (Ch.). — Le graissage rationnel et les roulements sur huile. — La théorie du film d'huile. (A ivre.) (6 800 mots & fig.)

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1929 625 .172

ɜnie civil, n° 2449, 20 juillet, p. 68.

Voiture spéciale des chemins de fer de l'Est, pour le ntrôle des voies avec l'appareil Hallade. (1 300 mots fig.)

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Les « freins à voie » permettent d'arrêter automatiquement les wagons isolés. (500 mots.)

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1929 621 .132.8

Les chemins de fer et les tramways, juillet, p. 146.

Considérations générales sur les automotrices à combustion interne et transmission électrique. (3 900 mots & fig.)

1929 621 .132.6 (.82)

Les chemins de fer et les tramways, juillet, p. 149.

Locomotive tender compound à 2 cylindres, type 2-4-2 des chemins de fer de l'Argentine Centrale. (2 200 mots & fig.)

1929 621 .335 & 621 .43

Les chemins de fer et les tramways, juillet, p. 151.

Utilisation des locomotives Diesel électriques comme locomotives de manœuvre. (1 300 mots.)

## L'Industrie des voies ferrées et des transports automobiles. (Paris.)

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ANDRIES (M.). — La récupération d'énergie sur les motrices de tramways. (8 000 mots & fig.)

1929 625 .62

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L'Ind. voies ferrées et transp. autom., juillet, p. 271.

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CHAPELON (A.). — Essais effectués par la Compagnie d'Orléans dans le but de rechercher les meilleurs moyens de combattre les rabattements de fumée sur les locomotives. (4 300 mots & fig.)

1929 385. (09 (.497.1)

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**Le développement des chemins de fer en Yougoslavie.** (6 300 mots.)

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**Locotracteurs Diesel** à transmission électrique. (3 000 mots & 4 tableaux.)

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1929 621 .116

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1929 624 .2

Revue universelle des mines, n° 3, 1er août, p. 71.

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WAGNER (G.). — Die **elektrische Beleuchtung** neuen Berliner Stadtbahnwagen mit versenkten De leuchten. (1 700 Wörter & Abb.)

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1929 621 .33 (

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1929 621 .33 (

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1929 621 .332 (.

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RAUCH (A.). — **Elektrische Zugheizung.** Wage den Übergangsverkehr, die sowohl mit 1 000 Wechselstrom wie mit 1 500 Volt Gleichstrom ge werden. (3 400 Wörter & Abb.)

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**Gelenkzug** der Städtischen Strassenbahn Dre (1 800 Wörter.)

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Die **Elektrisierung** der Osterreichischen Bundesba (500 Wörter.)

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1929 625 .1 (06 (08 (.73)
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1929 621 .132.3 (.42)
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### Engineering. (London.)

1929 625 .142.4
Engineering, No. 3312, July 5, p. 12.
The Emperger **reinforced-concrete sleeper.** (1 000 words & fig.)

1929 621 .13 (09.3 (.42)
Engineering, No. 3313, July 12, p. 52.
Rainhill **locomotive trials** centenary exhibition. (1 700 words & fig.)

### Engineering News-Record. (New York.)

1929 721 .1 (.73)
Engineering News-Record, No. 26, June 27, p. 1018.
WHITE (L.). — Supporting foundations exposed during Nassau Street **subway construction.** (3 500 words & fig.)

1929 656 .212 (.73) & 725 .33 (.73)
Engineering News-Record, No. 26, June 27, p. 1033.
Enlarged **freight yard** and engine terminal for Norfolk & Western Railway. (4 600 words & fig.)

### Great Western Railway Magazine. (London.)

1929 627
Great Western Ry. Magazine, August, p. 319.
CLEAVER (W.). — The removal and replacement of **lock gates.** (1 300 words & fig.)

### Journal of the Institute of Transport. (London.)

1929 385. (09.1 (.42)
Journal of the Institute of Transport, July, p. 425.
HORNSBY (Th.). — Characteristic features of the **transport facilities** of the North Eastern Area of the London & North Eastern Railway. (10 800 words.)

1929 656
Journal of the Institute of Transport, July, p. 438.
BEAUMONT (E. G. E.). — Influences affecting **transport development** and **efficiency.** (12 500 words.)

1929 656
Journal of the Institute of Transport, July, p. 453.
EDWARDS (I. A. E.). — **Internal air services** and **overseas connections.** (12 400 words.)

1929 385 .0 (.82)
Journal of the Institute of Transport, July, p. 485.
LESLIE (R.). — Some **present-day problems of Argentine railways.** (6 800 words.)

### Locomotive Railway Carriage & Wagon Review. (London).

1929 621 .132.3 (.44)
Loc. Ry. Carriage & Wag. Rev., No. 443, July 15, p. 205.
**Locomotive development** on the Eastern Railway of France. (1 400 words & fig.)

1929 621 .132.3 (.54)
Loc. Ry. Carriage & Wag. Rev., No. 443, July 15, p. 208.
**Compound Pacific Express locomotives**, Bengal-Nagpur Railway. (500 words & fig.)

1929 621 .132.5 (.82)
Loc. Ry. Carriage & Wag. Rev., No. 443, July 15, p. 212.
**« Mikado » type locomotives** : Buenos Ayres & Pacific Railway. (1 000 words & fig.)

1929 621 .132.8
Loc. Ry. Carriage & Wag. Rev., No. 443, July 15, p. 218.
**Petrol locomotive and transporter wagon**, Perak River Hydroelectric Power Company, Limited. (800 words & fig.)

1929 625 .242 (.54)
Loc. Ry. Carriage & Wag. Rev., No. 443, July 15, p. 221.
**New bogie coal wagons** for the Indian State Railways. (Broad gauge.) (600 words & fig.)

1929 621 .132.3 (.73)
Loc. Ry. Carriage & Wag. Rev., No. 443, July 15, p. 231.
POULTNEY (E. C.). — **Modern american express locomotives** (continued). (2 300 words & fig.)

## Mechanical Engineering. (New-York.)

1929 621 .116 & 669 .1
Mechanical Engineering, August, p. 589.
RECH (H. F.). — **Recent developments in boiler-metal embrittlement.** (2 900 words & fig.)

1929 621 .9
Mechanical Engineering, August, p. 596.
LONG (H. J.). & EDDY (W. P.). — **Tungsten carbide as a cutting-tool material.** (2 700 words.)

1929 621 .133.4 (.73)
Mechanical Engineering, August, p. 599.
COONRADT (A. C.). — **Steam-generating apparatus** in forest areas as related to causes of forest fires. (3 400 words & fig.)

1929 621 .9
Mechanical Engineering, August, p. 604.
**Cooling and lubrication of cutting tools.** (3 100 words & 2 tables.)

## Modern Transport. (London.)

1929 656 .254 (.73)
Modern Transport, No. 538, July 6, p. 3.
Underground railways of New York. **Train control methods** on the Brooklyn-Manhattan subway. (2 000 words & fig.)

1929 621 .132.8 (.42)
Modern Transport, No. 538, July 6, p. 9.
New **geared steam locomotive.** (800 words & fig.)

1929 621 .338 (.42)
Modern Transport, No. 538, July 6, p. 10.
**New rolling stock** on the London Underground. (300 words & fig.)

1929 656 .211.7 (
Modern Transport, No. 539, July 13, p. 3.
London & North Eastern Railway. North sea serv
New twin screw geared turbine steamer « Vienn
(2 100 words & fig.)

1929 625 .232 (
Modern Transport, No. 539, July 13, p. 7.
**New rolling stock** for Great Western Railway. (
words & fig.)

1929 656 .222.1 (
Modern Transport, No. 539, July 13, p. 9.
Progress in **train speeds.** (1 200 words & fig.)

## Proceedings, Institution of Civil Engineers (London.)

1929 624 .1 (.71) & 627 (
Proceed., Instit. of Civil Eng., vol. 226, p. 51.
WYNNE-EDWARDS (R. M.). — **Reinforced-con**
**piles** driven in a gravel fil at the Canadian Pacific
way Company's new pier B. C., at Vancouver, B
Canada. (26 000 words & fig.)

1929
Proceed., Instit. of Civil Eng., vol. 226, p. 117.
STROYER (R. N.). — **Earth-pressure** on fle
walls. (7 100 words & fig.)

## Proceedings, Institution of Mechanical Engine (London.)

1929 621
Proceed., Instit. of Mechanical Eng., January, p. 
WEIR (J. G.). — **Modern feed-water circuits.** (1
words & fig.)

## Proceedings, Institution of Railway Signal Engineers. (Manchester.)

1929 656
Proceed. Instit. Ry. Signal Eng., part II, Septe
1928 to January 1929, p. 167.
CHALLIS (W.), CROOK (G. H.) & GUYATT (G.
General meeting (London), November 14th 1928. S
papers on some recent **signalling developments** and
blems. (17 600 words & fig.)

1929 656
Proceed. Instit. Ry. Signal Eng., part II, Septe
1928 to January 1929, p. 213.
LEAKE (F. W.). — **Token instruments** and thei
in securing safety in single line working. (12 800 wo

## Railway Age. (New-York.)

1929 625 .26 (.73) & 656 .225 (
Railway Age, No. 25, June 22, Section one, p. 1405.
**Car conditioning.** — Vital factor in melon hand
(4 300 words & fig.)

1929 621 .139 (.73), 625 .18 (.73) & 625 .27 (.73)
Railway Age, No. 25, June 22, Section one, p. 1411.
The Union Pacific buys scientifically. (4 900 words & fig.)

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1929 625 .144.4 (.73)
Railway Age, No. 25, June 22, Section one, p. 1416.
The Western Pacific dresses up. (5 500 words & fig.)

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1929 621 .132.9 (.73), 625 .18 (.73) & 625 .27 (.73)
Railway Age, No. 25, June 22, Section one, p. 1427.
Vast purchases shed light on railway supply work. (5 600 words, 4 tables & fig.)

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1929 621 .138 (.73) & 725 .33 (.73)
Railway Age, No. 25, June 22, Section one, p. 1434.
Santa Fe builds for better locomotive maintenance. (3 500 words, 2 tables & fig.)

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1929 621 .132.9 (.73), 625 .18 (.73) & 625 .27 (.73)
Railway Age, No. 25, June 22, Section one, p. 1441.
Southern Pacific uses latest in supply work. (4 500 words & fig.)

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1929 625 .162 (.73) & 614 .8 (.73)
Railway Age, No. 25, June 22, Section one, p. 1447.
ENGELHARDT (H. L.). — Analysis of grade crossing accidents. (5 300 words, 4 tables & fig.)

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1929 621 .139 (.73), 625 .18 (.73) & 625 .26 (.73)
Railway Age, No. 25, June 22, Section one, p. 1454.
Railways reduce inventories. (1 800 words, 2 tables & fig.)

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1929 656 .1 (.73) & 656 .2 (.73)
Railway Age, No. 25, June 22, Section two, p. 1507.
Motor vehicles cut operating losses. (2 000 words & fig.)

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1929 656 .1 (.73) & 656 .2 (.73)
Railway Age, No. 25, June 22, Section two, p. 1512.
RUSSELL (A. P.). — New Haven motor coaches offer four classes of service. (1 600 words & fig.)

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1929 656 .1 (.73) & 656 .2 (.73)
Railway Age, No. 25, June 22, Section two, p. 1514.
FRITCH (H. F.). — Motor coaches and trucks help the Boston and Maine. (1 400 words & fig.)

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1929 656 .1 (.73) & 656 .2 (.73)
Railway Age, No. 25, June 22, Section one, p. 1517.
Is motor coach operation profitable? (1 300 words & fig.)

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1929 656 .261 (.73)
Railway Age, No. 25, June 22, Section one, p. 1525.
YOUNG (L. B.). — Modern conditions demand coordinated truck service. (1 000 words & fig.)

1929 656 .253 (.73)
Railway Age, No. 26, June 29, p. 1546.
SAUNDERS (J. E.). — Lackawanna modernizes signal system for automatic train control. (2 700 words & fig.)

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1929 625 .13 (.73)
Railway Age, No. 26, June 29, p. 1549.
Heavy repairs required after fire in Memphis bridge. (2 400 words & fig.)

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1929 621 .132.5 (.73)
Railway Age, No. 26, June 29, p. 1553.
Mikado type locomotive for the Georgia Northern. (600 words, 1 table & fig.)

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1929 656 .21 (06 (08 (.73)
Railway Age, No. 26, June 29, p. 1555.
Freight station section meets. (2 300 words & fig.)

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1929 385. (06.3 (08 (.73)
Railway Age, No. 26, June 29, p. 1563.
Superintendents conclude meeting in Mexico City. (1 200 words & fig.)

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1929 621 .139. (06 (08 (.73), 625 .18 (06 (08 (.73) & 625 .27 (06 (08 (.73)
Railway Age, No. 26, June 29, p. 1573.
Railway supply officers hold annual convention. (30 000 words, 4 tables & fig.)

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1929 621 .33 (.73)
Railway Age, No. 27, July 6, p. 5.
DAHL (H. A.). — Development of electric traction on the Pennsylvania. (3 500 words & fig.)

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1929 62. (01 (06 (.73)
Railway Age, No. 27, July 6, p. 9.
American Society for Testing Materials meets at Atlantic City. (3 000 words & fig.)

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1929 656 (.73)
Railway Age, No. 27, July 6, p. 13.
The Transcontinental Air Transport (T. A. T.) air rail service. (2 600 words & fig.)

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1929 656 .24 (06 (08 (.73)
Railway Age, No. 27, July 6, p. 22.
Claim men discuss ambulance chasing. (4 200 words & fig.)

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1929 621 .13 (06 (08 (.73) & 625 .2 (06 (08 (.73)
Railway Age, No. 27, July 6, p. 29.
Mechanical Division meets at Los Angeles. (215 000 words & fig.)

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1929 625 .245 (.71)
Railway Age, No. 2, July 13, p. 145.
Canadian Pacific business cars for General Superintendents. (1 500 words & fig.)

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1929 621 .33 (.725)
Railway Age, No. 2, July 13, p. 148.
COX (J. B.). — Performance of the Mexican Railway electrification. (4 200 words, 12 tables & fig.)

1929 624 .7 (.73)

Railway Age, No. 2, July 13, p. 154.

HIRSCHTHAL (M.). — Lackawanna builds two concrete bridges with unusual span lengths. (3 500 words & fig.)

1929 656 .259 (.73)

Railway Age, No. 3, July 20, p. 190.

WESTBAY (J. H.). — Big Four improves operation by remote control of switches and signals. (2 800 words, 1 table & fig.)

1929 625 .244 (.73) & 656 .225 (.73)

Railway Age, No. 3, July 20, p. 193.

**Handling perishables by rail.** (3 500 words & fig.)

1929 621 .138.2 (.73) & 725 .33 (.73)

Railway Age, No. 3, July 20, p. 196.

KAUFFMAN (H. L.). — The design of fuel-oil stations presents many problems. (4 500 words & fig.)

1929 621 .132.4 (.73)

Railway Age, No. 3, July 20, p. 201.

Delaware & Hudson **Pacific type locomotive.** (400 words, 1 table & fig.)

1929 625 .24 (0 (.73)

Railway Age, No. 3, July 20, p. 209.

Forty or fifty ton **box cars?** (3 200 words & fig.)

## Railway Engineer. (London.)

1929 625 .173 (.67)

Railway Engineer, August, p. 291.

**Permanent way** relaying in Central Africa. (700 words & fig.)

1929 621 .132.4 (.54)

Railway Engineer, August, p. 287.

**Four-cylinder 4-6-2 locomotives,** Bengal-Nagpur Railway. (900 words & fig.)

1929 656 .253 (.42)

Railway Engineer, August, p. 291.

The **re-signalling** of Victoria and Exchange stations, Manchester. (10 000 words & fig.)

1929 625 .233

Railway Engineer, August, p. 305.

COPPOCH (C.). — **Electric train-lighting equipment.** — I. (2 200 words & fig.)

1929 656 .255

Railway Engineer, August, p. 308.

Improved methods in the **operation of single tracks.** — IV. (To be continued.) (2 300 words & fig.)

1929 621 .132.6 (.460)

Railway Engineer, August, p. 319.

**Heavy tank locomotives** on the Madrid, Saragossa & Alicante Railway. (600 words & fig.)

## Railway Engineering & Maintenance. (Chicag

1929 385 .517.7 (.

Railway Engineering and Maintenance, July, p. 282

A home for the foreman or just a place to live. (5 words & fig.)

1929 621 .392 (.73) & 625 .13 (.

Railway Engineering and Maintenance, July, p. 28

SCHENKER (A. W.). — **Welding** proves effectiv repair of bridge. (1 400 words & fig.)

1929 614 .8 (.

Railway Engineering and Maintenance, July, p. 290

WARFEL (G. H.). — **Safety in maintenance of work brought up to date.** (5 700 words & fig.)

1929 625 .172 (.

Railway Engineering and Maintenance, July, p. 296

How good is your **track?** (2 700 words & fig.)

1929 625 .18 (.

Railway Engineering and Maintenance, July, p. 300

**Cost analysis** pays on the Chesapeake & Ohio. (1 words & fig.)

1929 625

Railway Engineering and Maintenance, July, p. 302

CLEVELAND (W. H.). — **Water pockets.** — they form and how to avoid them. (1 800 words &

## Railway Gazette. (London.)

1929 656 .253 (

Railway Gazette, No. 1, July 5, p. 9.

The **re-signalling** of Victoria and Exchange stati Manchester. (5 000 words & fig.)

1929 656 .211.7 (

Railway Gazette, No. 1, July 5, p. 18.

Inauguration of the Buenos Ayres **ferry termina** the Entre Rios Railways. (500 words & fig.)

1929 347 .75 (

Railway Gazette, No. 1, July 5, p. 24.

**How a railway corporation road pact operates.** words & fig.)

1929 625 .245 (.

Railway Gazette, No. 3, July 19, p. 103.

A travelling **rail dental clinic.** (1 400 words & fig

1929 725 .31 (

Railway Gazette, No. 3, July 19, p. 104.

**Buffalo Central station, New York Central** (800 words & fig.)

1929 625 .236 (

Railway Gazette, No. 3, July 19, p. 107.

**Carriage disinfection** plant at Potsdam shops. ( words.)

1929 656 .255
Railway Gazette, No. 3, July 19, p. 108.
The **operation of single lines** of railway. — II. (2 800 words & fig.)

1929 656 .254
Railway Gazette, No. 3, July 19, p. 110.
TAYLOR (F. G.). — **Effects of magnetic storms on railway safety.** (1 000 words.)

1929 656 .253 (.42)
Railway Gazette, No. 3, July 19, p. 111.
The **re-signalling** of the Mumbles Railway. (1 500 words & fig.)

1929 656 .255
Railway Gazette, No. 4, July 26, p. 140.
The **operation** of **single lines** of railway. III. (2 300 words.)

1929 656 .259 (.42)
Railway Gazette, No. 4, July 26, p. 143.
**Automatic points and remote junction control.** (2 600 words & fig.)

1929 385 .113 (.93)
Railway Gazette, No. 4, July 26, p. 148.
**German railways in 1928.** (1 600 words.)

1929 621 .132.5 (.54)
Railway Gazette, No. 4, July 26, p. 150.
**2-8-2 locomotives,** Madras & Southern Mahratta Railway. (1 200 words & fig.)

1929 621 .132.4 (.436)
Railway Gazette, No. 4, July 26, p. 152.
**New express locomotive** for the Austrian Federal Railways. (700 words & fig.)

1929 624 .32 (.944)
Railway Gazette, No. 4, July 26, p. 153.
**Hawkesbury bridge,** New South Wales Railways. (1 200 words & fig.)

## Railway Magazine. (London.)

1929 656 .211.7 (.42)
Railway Magazine, August, p. 87.
TRIPP (G. W.). — **British railways and non-railway steamers** (No. I). (To be continued.) (2 100 words & fig.)

1929 656 .222.1 (.44)
Railway Magazine, August, p. 98.
Recent **express locomotive work** in France. — II. Chemin de fer de l'Etat. (2 700 words & fig.)

1929 656 .222.1 (.42)
Railway Magazine, August, p. 108.
ALLEN (C. J.). — **British locomotive practice and performance.** (6 700 words & fig.)

## Railway Mechanical Engineer. (New-York.)

1929 385. (061.4 (08 (.73)
Railway Mechanical Engineer, July, p. 360.
American Railway Association. — **Mechanical division meets at Los Angeles.** (4 400 words & fig.)

1929 625 .216 (.73)
Railway Mechanical Engineer, July, p. 364.
American Railway Association. — Mechanical division. — Report on **couplers and draft gears.** (12 000 words, 3 tables & fig.)

1929 621 .138 (.73)
Railway Mechanical Engineer, July, p. 373.
American Railway Association. Mechanical division. — Report on **design of shops and engine terminals.** (3 500 words & fig.)

1929 62. (01 (.73)
Railway Mechanical Engineer, July, p. 375.
Report on **specifications and test for materials.** (3 600 words, 4 tables & fig.)

1929 625 .25 (.73)
Railway Mechanical Engineer, July, p. 380.
American Railway Association. — Report on **brakes and brake equipment.** (3 700 words & fig.)

1929 625 .212 (.73)
Railway Mechanical Engineer, July, p. 382.
American Railway Association. — Report of committee on **wheels.** (3 500 words & fig.)

1929 621 .134.5 (.73) & 625 .214 (.73)
Railway Mechanical Engineer, July, p. 386.
American Railway Association. — **Lubrication of cars and locomotives.** (10 300 words & fig.)

1929 625 .2 (.73)
Railway Mechanical Engineer, July, p. 396.
American Railway Association. — Report of committee on **car construction.** (11 300 words & fig.)

1929 625 .25 (.73)
Railway Mechanical Engineer, July, p. 421.
JOHNSON (H. A.). — American Railway Association. — Report on the **power-brake investigation.** (5 200 words, 2 tables & fig.)

1929 385 .586 (.73)
Railway Mechanical Engineer, July, p. 425.
American Railway Association. — Report of subcommittee on **apprentices.** (3 300 words & fig.)

1929 621 .13 (.73)
Railway Mechanical Engineer, July, p. 436.
American Railway Association. — Report on **locomotive design and construction.** (9 800 words, 3 tables & fig.)

1929 621 .133.1 (.73)
Railway Mechanical Engineer, July, p. 446.
American Railway Association. — **Utilization of locomotives and conservation of fuel.** (8 900 words & fig.)

## Railway Signaling. (Chicago.)

1929 656 .253 (.73)
Railway Signaling, July, p. 243.
STRADLING (E. G.). — Monon automatic train stop employs 360-cycle current. Part II. (3 400 words & fig.)

1929 656 .253 (.73) & 656 .255 (.73)
Railway Signaling, July, p. 248.
CASEY (M. J.). — Trains directed by signal indication in either direction on both tracks of busy double-track line. (2 000 words & fig.)

1929 656 .258 (.73)
Railway Signaling, July, p. 252.
Pennsylvania installs interlocking at Lancaster, Pennsylvania. (2 400 words & fig.)

1929 62. (01
Railway Signaling, July, p. 258.
HILL (F. J.). — A study of methods for testing insulation resistance. (2 100 words & fig.)

1929 656 .253 (.73)
Railway Signaling, July, p. 263.
Report on Pennsylvania's coded train-stop system. (1 100 words.)

1929 656 .259 (.73)
Railway Signaling, July, p. 264.
MOLLOY (J. H.). — Automatic interlocker replaces 25-year old mechanical plant. (1 300 words & fig.)

## South African Railways and Harbours Magazine (Johannesburg.)

1929 651 (.68)
South African Rys. & Harbours Mag., June, p. 881.
Accounting by mechanical devices. — Machines in use on the South African Railways. (1 300 words & fig.)

1929 725 .33 (.68)
South African Rys. & Harbours Mag., June, p. 886.
Sidelights on the working at a big railway depot. (2 000 words & fig.)

1929 385. (09.1 (.931)
South African Rys. & Harbours Mag., June, p. 894.
The railways of New Zealand. (2 700 words & fig.)

1929 385. (09.1 (.593)
South African Rys. & Harbours Mag., June, p. 901.
FORAN (W. R.). — Siam : A model oriental kingdom. (3 600 words & fig.)

## University of Illinois Bulletin. (Urbana.)

1929 62. (01 & 693
University of Illinois Bulletin, No. 44, July 2, p. 5.
WESTMAN (A. E. R.). — An X-ray study of fire-brick. (2 700 words & fig.)

### In English.

## Gaceta de los Caminos de hierro. (Madrid

1929 621 .138.1 (
Gac. de los Cam. de hierro, nº 3589, 1º de Julio, p.
Nuevas instalaciones para los depósitos de locom ras. (1 300 palabras.)

1929 385. (09 (.
Gac. de los Cam. de hierro, nº 3590, 10 de Julio, p.
— — nº 3591, 20 de Julio, p.
Los ferrocarriles checoeslovacos. (3 800 palabras.)

## Revista de Obras Públicas. (Madrid.)

1929 625 .112 (.
Revista de Obras Públicas, nº 13, 1º de Julio, p. 24
PAZ (J.). — El ancho de via de los ferrocar españoles. (2 000 palabras.)

1929 624
Revista de Obras Públicas, nº 13, 1º de Julio, p. 25
La aplicación de los formularios oficiales de tra de hormigón armado para carreteras. (300 palabra 1 tabla.)

1929 621 .1 (.44 + .
Revista de Obras Públicas, nº 14, 15 de Julio, p. 26
Ferrocarril transpirenaico de Ripoll a Ax-les-Ther (13 500 palabras.)

1929 625
Revista de Obras Públicas, nº 15, 1º de Agosto, p.
MACHIMBARRENA (V.). — El ancho de via de ferrocarriles españoles. (2 900 palabras.)

### In Italian.

## Annali dei lavori pubblici. (Roma.)

1929 72
Annali dei lavori pubblici, Aprile, p. 319.
MIOZZI (E.). — Le sollecitazioni nelle piccole v (6 900 parole & fig.)

1929 621 .13 & 621
Annali dei lavori pubblici, Maggio, p. 389.
BAJOCCHI (U.). — Determinazione delle caratt tiche fondamentali di una ferrovia elettrica equival ad una ferrovia a vapore di caratteristiche note. (17 parole & 5 quadri.)

## L'Ingegnere. (Roma.)

1929 621
L'Ingegnere, Giugno, p. 330.
DE MARCO (M.). — La trazione elettrica ferrovi (17 600 parole & fig.)

sta tecnica delle ferrovie italiane. (Roma.)

29 385 (.4)

tecnica delle ferrovie ital., n° 6, 15 Giugno, p. 245.

)STI (L.). — **Rilievi sulla situazione attuale di al- reti Ferroviarie Europee.** (9 000 parole & 10 qua-

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)29 625 .251

tecnica delle ferrovie ital., n° 6, 15 Giugno, p. 264.

)RBELLINI (G.). — **Nuovi abachi di frenatura dei i.** (Continua.) (9 900 parole.)

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)29 625 .113

tecnica delle ferrovie ital., n° 6, 15 Giugno, p. 284.

IOVENE (N.). — **L'armamento in curva.** (1 900 pa- & fig.)

1929 625 .143.2

Riv. tecnica delle ferrovie ital., n° 6, 15 Giugno, p. 290.

ABBOLITO (F.). — **L'andamento del numero di urti ripetuti alterni nelle varie zone della rotaia.** (900 parole & fig.)

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**In Dutch.**

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## De Locomotief. (Amsterdam.)

1929 656 .1 & 656 .2

De Locomotief, Nr 31, 31 Juli, p. 241.

**Automobielen tot spoorwegrijtuigen omgebouwd.** (400 woorden.)

# MONTHLY BIBLIOGRAPHY OF RAILWAYS [1]

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[ 016 .385 (02 ]

## I. — BOOKS.

### In French.

1929 669 .1

USQUET (C.), Contrôleur technique.

**La fabrication de la fonte malléable.**

Paris (6e), Dunod, rue Bonaparte, 92. Un volume 6 × 25 cm.), VIII, 160 pages & 144 figures. (Prix : francs.)

1929 621 .43

CORCHON (F.), Ingénieur-mécanicien.

**Le moteur Diesel** et ses dérivés. — Moteurs à boule aude et moteurs à précombustion.

Paris, Delagrave. Un volume in-8° de 533 pages. Prix : 90 francs.)

1929 621 .9 (02

ERLOT (Jules).

**Guide de l'ajusteur.**

Paris (6e), Ch. Béranger, 15, rue des Saints-Pères. volume in-8° (16 × 25 cm.) de 318 pages et 510 fi- res. (Prix : 60 francs.)

1929 625 .162 (.494) & 656 .254 (.494)

Ordonnance fédérale du 7 mai 1929 concernant la rmeture et la **signalisation des croisements à niveau** chemins de fer avec les routes et chemins publics.

Berne, bureau des imprimés de la Chancellerie fédé- e.

1929 624 .63

EINSBERG (R. E.).

**Arcs et portiques en béton armé.**

Paris (6e), 15, rue des Saints-Pères; Liége, 1, quai la Grande-Bretagne. Librairie polytechnique Ch. ranger. Un volume in-8° (16 × 25 cm.) de 138 pages 53 figures. (Prix : 70 francs.)

### In German.

1929 656 .21 (.4)

Dr. KOCHS, Stationsverzeichnis.

**Stationsverzeichnis der Eisenbahnen Europas.** Teil I : Geographisches Stationsverzeichnis; Teil II : Alphabetisches Stationsverzeichnis.

Berlin, Wilmersdorf, Melitzstrasse, 3.

1929 656 .215

SCHÜTZ (Edmund) & WAGNER (Gustav), Reichsbahnoberräte.

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New York City, H. S. Balliet, secretary of the Association, 30 Vesey Street. (6 × 9 1/4 inches), 1 007 pages. (Price : $ 8.00.)

[1] The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly h the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to Railway Science », by Weissenbruch in the number of November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509).

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1929 656 .23 (.73)

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**Port and terminal charges at United States ports.**

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1929 621 .139 & 625 .27

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**Stores accounts and stores control.**

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1929 656 .24 (.73)

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1929 62. (01 & 625 .216

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Tests of freight car **draft gears.**

Lafayette, Ind. Purdue University. Bulletin n° 35. (6 × 9 inches), 313 pages.

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1929 621 .392

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Properties and manufacture of **concrete building units.**

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1929 385. (07 (.42)

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1929 656. (02

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1929 656 .23

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1929 651 & 657
CHNAKEL (H. G.) & LANG (Henry, C.).
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Field engineering : A handbook of the theory and ractice of railway surveying, location and construcion.
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1929 526. (02
WHITELAW (J.).
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### Annales des Mines. (Paris.)

1929 536
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SOCHACZEWER (M. D.). — Note sur les connaisances actuelles des propriétés de la vapeur d'eau. (A suivre.) (13 800 mots & 5 tableaux.)

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### Annales des travaux publics de Belgique. (Bruxelles.)

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BLOCKMANS (J.). — Le nouveau tunnel pour trafic routier sous la Mersey. (1 900 mots & fig.)

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1929 624 .2
Arts et Métiers, août, p. 284.
Les poutres continues. (1 700 mots, 1 tableau & fig.)

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1929 621 .112
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PACORET (E.). — Evolution de la vapeur à très haute tension. (A suivre.) (9 000 mots & fig.)

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### Bulletin de la Société d'encouragement pour l'industrie nationale. (Paris.)

1929 01. (06 (.44)
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1929 621 .135.4 & 625 .215
Bull. de la Soc. des ing. civ. de France, mars-avril, p. 424.
MESTRE (H. C.). — Inscription des véhicules dans la voie ferrée. (10 300 mots & fig.)

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1929 621 .135.2 & 625 .214
Bull. de la Soc. des ing. civ. de France, mars-avril, p. 453.
FRONTARD (P.). — La construction et l'emploi des boîtes d'essieux à rouleaux. (3 800 mots & fig.)

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1929 62. (01
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TIRASPOLSKY (G.). — Détermination des moments du 1er et du 2e degré et des centres de gravité des aires planes à l'aide d'un planimètre. (1 700 mots & fig.)

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1929 313 .385 (.43)
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### Bulletin technique de la Suisse romande. (Vevey.)

1929 656 .1
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Les cars alpins « Saurer ». (400 mots & fig.)

1929 62. (01 & 691
Bull. techn. de la Suisse romande, n° 17, 24 août, p. 193.
BOLOMEY (J.). — Détermination de la résistance probable d'un béton connaissant son dosage et sa densité au moment du gâchage. (2 300 mots & fig.)

1929 625 .162 (.494) & 656 .254 (.494)
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HUNZIKER (M. H.). — La nouvelle ordonnance fédérale du 7 mai 1929 sur la protection des **passages à niveau.** (2 900 mots.)

## Génie civil. (Paris.)

1929 625 .1 (.44 + .460)
Génie civil, n° 2451, 3 août, p. 101.

DANTIN (Ch.). — **Les chemins de fer transpyrénéens.** Inauguration de la ligne d'Ax-les-Thermes à Puigcerda. (6 000 mots & fig.)

1929 621 .392
Génie civil, n° 2451, 3 août, p. 116.

Applications diverses de la **soudure électrique à l'arc.** (1 400 mots.)

1929 624 .2
Génie civil, n° 2452, 10 août, p. 130.

Résistance des matériaux. — **Le flambement des arcs.** (1 500 mots & fig.)

1929 62. (01
Génie civil, n° 2452, 10 août, p. 139.

Les **essais de choc** sur barreaux entaillés. (700 mots.)

1929 62. (01
Génie civil, n° 2453, 17 août, p. 159.

PORTEVIN (A.) & LE CHATELIER (F.). — Les essais à chaud des métaux et alliages par compression et par filage. (800 mots.)

1929 625 .62 (.71)
Génie civil, n° 2453, 17 août, p. 159.

La nouvelle **organisation des tramways** de Montréal. (900 mots & fig.)

1929 385. (09 (.59)
Génie civil, n° 2454, 24 août, p. 169.

JOITEL (A.). — **Les chemins de fer de l'Indochine.** (6 300 mots & fig.)

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1929 625 .62 (.42)
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Les nouvelles **voitures à impériale** des tramways de Londres. (600 mots & fig.)

## L'Industrie des voies ferrées et des transports automobiles. (Paris.)

1929 625 .151
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GERARD (J.). — Aiguillage pour diagonale de secours évitant toute solution de continuité des rails de la voie principale. (600 mots & fig.)

1929 625
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VENTE. — Progrès réalisés dans le **freinage des t[ram]ways.** — Rapport présenté au XXI[e] Congrès inte[rna]tional de Rome (6-12 mai 1928). (6 300 mots & fig

## Revue de l'Ecole polytechnique. (Bruxelles.

1929 62.
BIRGUER (A.). — **Le calcul des systèmes hyper[sta]tiques** par la méthode focale. (Suite.) (2 300 mot[s &] fig.)
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1929 621 .1
Revue générale des chemins de fer, août, p. 109.

WIENER (L.). — Les **locomotives articulées actue[lles].** (Suite.) (12 200 mots & fig.)

1929 656 .256.3 (
Revue générale des chemins de fer, août, p. 131.

JOLY. — Installations récentes de **block-automat[ique]** par circuits de voie de la Compagnie du chemin de [fer] métropolitain de Paris. (7 300 mots & fig.)

1929 385 .113 (
Revue générale des chemins de fer, août, p. 148.

**Les résultats de l'exploitation** des cinq grandes c[om]pagnies de chemins de fer en 1928. (23 500 mots.)

1929 385. (09 (.4
Revue générale des chemins de fer, août, p. 189.

Chronique des chemins de fer. — **La réorganisa[tion] des chemins de fer roumains.** (4 700 mots & carte.)

1929 656 .1 & 65
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**Coopération entre chemin de fer et automobile.** (2 mots & fig.)

1929 621 .134.3 (
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**La locomotive Schmidt à haute pression.** Résultats essais effectués jusqu'à présent. (1 300 mots.)

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Revue générale des chemins de fer, août, p. 204.

Etude comparative de la **locomotive à vapeur** et différents types de **locomotives Diesel** au point de économique. (1 400 mots.)

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1929 341 .324 (
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Le conflit sino-soviétique et **le chemin de fer de l'** chinois. (2 000 mots.)

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BABILLION (L.). — **L'électrification des chemins de r de banlieue et des lignes de rabattement.** (2 400 ots & fig.)

1929 625 .216

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LIMON (F.). — **L'attelage automatique** des véhicules chemins de fer. (2 300 mots.)

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BASELER & BECKER. — Das **Verhalten langrad-ändiger Lokomotiven in Gleiskrümmungen** mit und ne Spurerweiterung. (13 600 Wörter, 5 Tafeln & bb.)

1929 625 .234

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RANCH (A.). — **Elektrische Zugheizung.** (Schluss.) 400 Wörter & Abb.)

1929 621 .335

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DRESCHER (H.). — Beitrag zur Frage der Anfahr-öglichkeit von **elektrischen Lokomotiven** mit ange-ngter Zuglast. (Schluss folgt.) (3 800 Wörter & Abb.)

1929 624 .2

ektrische Bahnen, Augustheft, S. 257.

KRUMMEL (K.). — Zur Bestimmung der **Tragfähig-it von I- Trägermasten.** (2 200 Wörter, 4 Tafeln & bb.)

## Glasers Annalen. (Berlin.)

1929 625 .62 (.431)

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WAGNER (G.). — Die neuen elektrischen Berliner **adtbahnwagen** unter besonderer Berücksichtigung rer Massenherstellung. (Schluss.) (3 700 Wörter & bb.)

1929 656

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de GRAHL. — Vorteile eines **Bahnbetriebs** mit asserstoff. (1 900 Wörter & Abb.)

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1929 621 .33 (.73)

Electric Railway Journal, August, p. 769.

**Lackawanna electrification.** (1 200 words & fig.)

1929 385. (07 (.73) & 385 .586 (.73)

Electric Railway Journal, August, p. 773.

Conference method effective for **training employees.** (1 500 words.)

1929 62. (01 & 669 .1

Electric Railway Journal, August, p. 775.

EWING (D. D.). — What happens when steel gets tired. (1 600 words, 6 tables & fig.)

1929 621 .31 (.71)

Electric Railway Journal, August, p. 779.

de ANGELIS (M. L.). — Montreal tramways extends use of **mercury arc rectifiers.** (1 200 words & fig.)

1929 625 .12 (.73) & 625 .14 (.73)

Electric Railway Journal, September, p. 824.

HOWARD (H. G.). — Small details important in trackwork. (2 900 words & fig.)

1929 62. (01 & 691

Electric Railway Journal, September, p. 829.

EWING (D. D.). — **Fatigue in concrete.** — An element to be taken into account in design. (1 000 words & fig.)

1929 621 .336 (.71)

Electric Railway Journal, September, p. 833.

**Bow collectors.** — Arc developed successfully in Toronto. (900 words & fig.)

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1929 62. (01 & 669

Engineer, No. 3836, July 19, p. 61.

HANKINS (G. A.). — The **hardness and abrasion testing of metals** (to be continued). (5 600 words & fig.)

1929 656 .212.6 (.42)

Engineer, No. 3838, August 2, p. 117.

**Mechanical coal loading plant** at Ellesmere port. (2 000 words & fig.)

1929 621 .132.8 (.68)

Engineer, No. 3838, August 2, p. 128.

An **articulated locomotive** for South Africa. (600 words & fig.)

1929 62. (01 & 669 .1

The Metallurgist, p. 100, supplement to the Engineer No. 3315, July 26.

The relation between **impact strength and « static » properties.** (1 400 words.)

1929 62. (01 & 669 .1
The Metallurgist, p. 107, supplement to the Engineer No. 3315, July 26.

HATFIELD (W. H.). — **Permanence of dimensions under stress** (to be continued). (1 100 words.)

1929 62. (01 & 669 .1
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**The effect of temperature on rust-resisting steel.** (700 words & 1 table.)

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1929 624 .1 (.73)
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SKINNER (F. W.). — The **righting of a foundation caisson** for the Poughkeepsie suspension bridge, New York. (3 300 words & fig.)

1929 62. (01
Engineering, No. 3315, July 26, p. 97.

ROWELL (H. S.). — A new **high-speed fatigue testing machine.** (2 300 words & fig.)

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1929 62. (01 (06 (08 (.73)
Engineering News-Record, No. 2, July 11, p. 63.

Committee work and research results reported at American Society for Testing Materials meeting. (4 300 words & fig.)

1929 625 .122 (.43)
Engineering News-Record, No. 3, July 18, p. 84.

KRAUTH (Th.). — **Large-volume earth-handling equipment** in Germany. (2 500 words & fig.)

1929 621 .392 (.73) & 665 .882 (.73)
Engineering News-Record, No. 3, July 18, p. 92.

Provisions of Welding Society code for structural welding. (2 400 words.)

1929 625 .4 (.86)
Engineering News-Record, No. 4, July 25, p. 127.

FAWCETT (R.). — General traffic **cable tramways** in Colombia. (1 500 words & fig.)

1929 624 .8 (.73)
Engineering News-Record, No. 4, July 25, p. 134.

**Raising 322-ft. lift span** from bottom of bay. (1 600 words & fig.)

1929 625 .13 (.44)
Engineering News-Record, No. 4, July 25, p. 138.

**Tunnel repaired with precast concrete invert beams.** (1 600 words & fig.)

1929 625 .1 (.73)
Engineering News-Record, No. 5, August 1, p. 168.

Frisco line builds a 293-mile extension to Tidewater. (1 600 words & fig.)

1929 725
Engineering News-Record, No. 6, August 8, p. 211.

Locomotive repair shops: **Design and equipm** (1 100 words.)

1929 625 .13 (
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WIERSEMA (H. A.). — **Harahan bridge repa after fire without dismantling.** (1 200 words & fig

1929 624 .2 &
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PAULET (E. G.). — Spacing suspension points **precast concrete piles.** (1 500 words & fig.)

1929 621 .392 & 624
Engineering News-Record, No. 8, August 22, p. 292.

FISH (G. D.). — Specification for **arc-welded con**tions in bridges. (7 100 words & fig.)

1929 656 .211 (
Engineering News-Record, No. 8, August 22, p. 301

Municipal **car-ferry terminal** for harbor at Milw kee, Wis. (2 300 words & fig.)

1929 625 .245 (
Engineering News-Record, No. 8, August 22, p. 304

High-capacity **dynamometer car** for Northern Pa Railway. (900 words & fig.)

1929 656 .212. (
Engineering News-Record, No. 9, August 29, p. 325.

**Freight station** with air-rights warehouse at Chic (1 300 words & fig.)

1929 721 .7 (
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MILLER (L. H.). — New **steel floor** developed building use. (1 300 words & fig.)

1929 624
Engineering News-Record, No. 9, August 29, p. 336.

SLACK (S. B.). — Measuring strain and t perature in a **160-ft. concrete arch bridge.** (2 600 w & fig.)

1929 624 .2 (.73) & 624 .8 (
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PAINE (C. E.). — Analysis of **dynamic stresse** Hackensack bascule. (5 700 words & fig.)

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1929 625 .172 (
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HUTT (E. T.). — **Testing the running** on the G Western Railway. (1 400 words & fig.)

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1929 624. (.9
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CHAPMAN (W. D.). — Spencer Street bridge. I **Subaqueous foundation work.** (6 700 words & fig.)

1929 624 .63 (.945)
nstitution of Engineers, Australia, June, p. 221.
HUGHES (H.). — Spencer Street bridge. II. — **Concrete work.** (6 300 words & fig.)

1929 621 .31 (.73)
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BRAIN (V. J. F.). — Recent advances in **transmision and distribution** in the United States. (22 300 words & fig.)

## Locomotive Railway Carriage & Wagon Review. (London).

1929 621 .132.7 (.42)
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The **locomotives** of **Lever Bros. Railways,** Port Sunight. (1 700 words & fig.)

1929 621 .131
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PHILLIPSON (E. A.). — **Steam locomotive** design : ata and formulæ. (To be continued.) (2 000 words & table.)

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SAMS (J. G. B.). — Modification of British **goods** quipment. (1 500 words.)

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1929 669 .1
echanical Engineering, September, section one, p. 667.
QUAID (Mc. H. W.). — **Surface hardening of steel** y **nitrogen.** (5 300 words & fig.)

## Modern Transport. (London.)

1929 621 .122.5 (.54)
odern Transport, No. 540, July 20, p. 3.
British-built **locomotives** for India. (1 600 words & g.)

1929 625 .13 (.6)
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**Railway bridges** in East and South Africa. (1 700 ords & fig.)

1929 625 .13 (.42)
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**Charing Cross bridge scheme.** (3 700 words & fig.)

1929 385 .113 (.43)
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**Developments on the German Railways.** (1 700 words.)

1929 625 .258 & 656 .212.5
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BYROM (C. R.). — **Design and operation of marhalling yards.** (5 300 words & fig.)

1929 656 .1 (.42) & 656 .2 (.42)
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Scottish road-rail merger. — Formation of large company. (300 words.)

1929 656 .1 (.43) & 656 .2 (.43)
Modern Transport, No. 542, August 3, p. 4.
**Road transport in Germany.** — How the railways are meeting competition. (2 800 words & fig.)

1929 621 .132.7 (.42) & 621 .43 (.42)
Modern Transport, No. 542, August 3, p. 7.
A new **Diesel shunting locomotive.** (1 600 words & fig.)

1929 38 & 656
Modern Transport, No. 542, August 3, p. 10.
JOHNSTONE (Ph.). — **Motor transport** for roadless countries. (3 400 words & fig.)

1929 625 .236 (.73)
Modern Transport, No. 542, August 3, p. 19.
Saving in **car washing.** — New methods in United States. (800 words & fig.)

## Proceedings, American Society of Civil Engineers. (New-York.)

1929 691
Proceed. Amer. Soc. civil Eng., August, part I, p. 1503.
VENABLE (W. M.). — **Measuring materials for concrete.** (9 400 words & 7 tables.)

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1929 656 .212 (.73)
Railway Age, No. 4, Section one, July 27, p. 234.
**New York Central plans extensive improvements** on West side in New York. (5 900 words & fig.)

1929 385 .21 (.71 + .73)
Railway Age, No. 4, Section one, July 27, p. 241.
St. Lawrence **waterway construction** found not justified. (5 300 words & fig.)

1929 656 .223.2 (.73)
Railway Age, No. 4, Section one, July 27, p. 247.
Transportation of **private cars must** be paid for. (5 300 words & fig.)

1929 621 .335 (.73) & 621 .4 (.73)
Railway Age, No. 4, Section one, July 27, p. 251.
Rock Island tests powerful **rail motor cars.** (2 500 words & fig.)

1929 385 .21 (.73)
Railway Age, No. 4, Section one, July 27, p. 255.
Engineers hear divergent views on **inland waterways.** (5 000 words & fig.)

1929 656 .2 (.73)
Railway Age, No. 4, Section one, July 27, p. 259.
**Rebuilding a railroad's operating methods.** — Part I. (1 900 words & fig.)

1929 656 .2 (06 (.73)
Railway Age, No. 4, Section two, July 27, p. 287.
Uniform specifications code revised. (8 600 words.)

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1929 656 .1 (.73) & 656 .2 (.73)
Railway Age, No. 4, Section two, July 27, p. 297.
BROSSEAU (A. J.). — **The motor truck.** — A helper, not a competitor, of the railways. (2 300 words & fig.)

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1929 656 .2 (.73)
Railway Age, No. 4, Section two, July 27, p. 307.
**Cost of motor coach operation** analyzed. (3 600 words.)

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1929 625 .13 (.73)
Railway Age, No. 5, August 3, p. 330.
Old spans serve as **falsework** for new spans. (3 000 words & fig.)

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1929 625 .242 (.73)
Railway Age, No. 5, August 3, p. 339.
Santa Fe **gondola** has **cast steel underframe.** (1 000 words & fig.)

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1929 621 .133.1 (.73)
Railway Age, No. 5, August 3, p. 345.
BJORKHOLM (J. E.). — Important factors in obtaining **fuel economy.** (2 100 words & fig.)

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1929 385 .517.6 (.73)
Railway Age, No. 5, August 3, p. 347.
Physical examination of employees. (3 200 words.)

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1929 656 .254 (.73)
Railway Age, No. 6, August 10, p. 370.
North Western expedites trains with centralized control. (1 900 words & fig.)

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1929 625 .232 (.73)
Railway Age, No. 6, August 10, p. 373.
Pennsylvania **multiple-unit cars** with aluminium bodies. (1 000 words, 4 tables & fig.)

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1929 656 .211 (.73)
Railway Age, No. 6, August 10, p. 375.
Cincinnati's Union Station plan embodies distinctive features. (2 500 words & fig.)

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1929 621 .139 (.73), 625 .18 (.73 & 625 .27 (.73)
Railway Age, No. 6, August 10, p. 378.
WALSH (C. E.). — How the Pennsylvania buys. (2 200 words & fig.)

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1929 625 .232 (.73)
Railway Age, No. 6, August 10, p. 381.
Soo line **buffet-lounge cars.** (1 300 words & fig.)

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1929 656 .2 (.73)
Railway Age, No. 6, August 10, p. 383.
Rebuilding a **railroad's operating methods.** — Part II. (3 000 words & fig.)

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1929 625 .121
Railway Age, No. 6, August 10, p. 386.
FETTERMAN (G. E.). — Conservation of railroad frontage for industry. (2 300 words & fig.)

1929 656 .213
Railway Age, No. 7, August 17, p. 410.
Missouri Pacific builds **new stock** pens at Pros
Mo. (2 000 words & fig.)

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1929 621 .132.3 (.71) & 621 .132.5
Railway Age, No. 7, August 17, p. 414.
**4-8-4 type** locomotive for the Canadian Nati
(1 600 words, 1 table & fig.)

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1929 656 .223.2
Railway Age, No. 7, August 17, p. 419.
BEGIEN (R. N.). — Making the most of **freight**
(2 400 words & fig.)

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1929 621 .133.7
Railway Age, No. 7, August 17, p. 421.
**Bird-archer type B sludge remover.** (600 word
fig.)

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1929 621 .139 (.73), 625 .18 (.73) & 625 .27 (
Railway Age, No. 7, August 17, p. 422.
KRAMPF (L. P.). — Missouri Pacific operates
get for **inventories.** (1 200 words & fig.)

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1929 625 .162 (.73) & 656 .259 (
Railway Age, No. 7, August 17, p. 425.
North Shore Line installs **automatic highway cros**
**gates.** (1 000 words & fig.)

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1929 651 (
Railway Age, No. 7, August 17, p. 429.
THAYER (V. D.). — How the Delaware, La
wanna & Western uses **tabulating machines.** (3
words & fig.)

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1929 659 (
Railway Age, No. 8, Section one, August 24, p. 451
McGINNIS (F. C.) & INGRAM (K. C.). — South
Pacific adopts **novel advertising copy.** (2 700 word
fig.)

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1929 625 .1 (.44 +
Railway Age, No. 8, Section one, August 24, p. 453
LIVINGSTON (F. C.). — **Outstanding feature** of
Nice-Coni Railway. (1 600 words & fig.)

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1929 621 .132.3 (
Railway Age, No. 8, Section one, August 24, p. 457
Denver & Rio Grande Western buys ten **4-8-4**
**locomotives.** (1 000 words, 1 table & fig.)

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1929 656 .223.2 (
Railway Age, No. 8, Section one, August 24, p. 459
AYLWARD (R. B.). — Saving a million dollars
**car hire.** (2 700 words & 2 tables.)

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1929 656 .254 (
Railway Age, No. 8, Section one, August 24, p. 462
ROGERS (W.). — Missouri Pacific speeds up ter
**nal operation.** (900 words & fig.)

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1929 385 .3 (.73) & 656 .261 (
Railway Age, No. 8, Section one, August 24, p. 467
Interstate Commerce Commission favors **trucking**
New York. (7 000 words.)

1929 725 .33 (.73)
ilway Age, No. 8, Section one, August 24, p. 473.
New type of **storage for locomotive sand.** (300 words fig.)

1929 656 .1 (.73) & 656 .2 (.73)
ilway Age, No. 8, Section two, August 24, p. 492.
MONTGOMERY (E. S.). — The story of the New ngland Transportation Company. (4 900 words & fig.)

1929 656 .1 (.73)
ilway Age, No. 8, Section two, August 24, p. 499.
Organization of a metropolitan **trucking service.** 800 words & fig.)

1929 656 .2 (.73)
ilway Age, No. 8, Section two, August 24, p. 503.
The problems of buying **motor coach lines.** (2 000 rds & fig.)

1929 656 .261 (.73)
ilway Age, No. 8, Section two, August 24, p. 505.
JOHNSON (T. A.). — A study of **co-operative truck-g.** (1 600 words & fig.)

1929 656 .1 (.42) & 656 .2 (.42)
ilway Age, No. 8, Section two, August 24, p. 507.
ARTHURTON (A. W.). — **British roads enter agree-ent with highway employees.** (2 100 words & fig.)

## Railway Engineer. (London.)

1929 625 .173 (.67)
ilway Engineer, August, p. 285.
**Permanent way relaying** in Central Africa. (700 rds & fig.)

1929 621 .132.3 (.54)
ilway Engineer, August, p. 287.
**Four-cylinder 4-6-2 locomotives,** Bengal-Nagpur Rail-ay. (1 700 words & fig.)

1929 656 .253 (.42)
ilway Engineer, August, p. 291.
The **re-signalling** of Victoria and Exchange stations, anchester. (7 000 words & fig.)

1929 625 .234
ilway Engineer, August, p. 305.
COPPOCK (C.). — **Electric train-lighting equipment.** I. (2 000 words & fig.)

1929 656 .255 (.42)
ilway Engineer, August, p. 309.
Improved methods in the **operation of single tracks.** IV. (To be continued.) (2 400 words & fig.)

1929 621 .132.6 (.460)
ilway Engineer, August, p. 319.
**Heavy tank locomotives** on the Madrid, Saragossa & licante Railway. (700 words & fig.)

1929 621 .134.1
Railway Engineer, August, p. 329.
Some recent improvements in **point rodding construction.** (2 300 words & fig.)

1929 621 .132.8 (.68)
Railway Engineer, August, p. 333.
Large **Beyer-Garratt locomotive** for South Africa. (1 800 words & fig.)

1929 625 .234
Railway Engineer, August, p. 337.
COPPOCK (C.). — **Electric train-lighting equipment.** — II. (2 200 words, 1 table & fig.)

1929 625 .23 (.8)
Railway Engineer, August, p. 341.
WILLANS (G.). — A new method of **railway carriage production.** (1 800 words & fig.)

1929 621 .131.1
Railway Engineer, September, p. 346.
GRIME (T.). — **Locomotive boiler power rating.** (3 000 words & fig.)

1929 656 .255 (.42)
Improved methods in the **operation of single tracks.**
Railway Engineer, September, p. 349.
— V. (To be continued.) (2 500 words & fig.)

1929 625 .214
Railway Engineer, September, p. 353.
**The design, application and operation of railway roller bearings.** — I. (2 600 words & fig.)

1929 625 .113
Railway Engineer, September, p. 357.
HEARN (G.). — **The realignment of railway curves.** — I. (1 900 words & fig.)

## Railway Engineering & Maintenance. (Chicago.)

1929 385 .517.7 (.73)
Railway Engineering and Maintenance, August, p. 326.
**Housing** on the Southern Pacific. (2 600 words & fig.)

1929 625 .17 (.73)
Railway Engineering and Maintenance, August, p. 330.
The country's most difficult **track maintenance.** (3 900 & fig.)

1929 725 .31 (.73)
Railway Engineering and Maintenance, August, p. 335.
Burlington modernizes **passenger stations.** (1 600 words & fig.)

1929 625 .173 (.73)
Railway Engineering and Maintenance, August, p. 337.
How an 1 800 feet **track pan** was renewed in 155 minutes. (1 100 words & fig.)

1929 625 .13 (.73)
Railway Engineering and Maintenance, August, p. 338.
**Prompt repair work saves bridge spans.** (1 300 words & fig.)

1929 625 .13 (.73) & 691 (.73)
Railway Engineering and Maintenance, August, p. 341.
**Slabs weighing 240 tons are moved on rollers.** (1 400 words & fig.)

1929 625 .17 (.3)
Railway Engineering and Maintenance, August, p. 343.
HEARN (G.). — Around the world with the track man. (4 000 words & fig.)

1929 625 .142.2 (.73) & 691 (.73)
Railway Engineering and Maintenance, August, p. 347.
GIBSON (A.). — 20 years of **treated ties** on the Northern Pacific. (1 500 words & fig.)

## Railway Gazette. (London.)

1929 621 .132.8 (.68)
Railway Gazette, No. 5, August 2, p. 181.
The largest and most powerful **3-ft. 6-in. gauge locomotive** in the world. (1 600 words & fig.)

1929 656 .255
Railway Gazette, No. 5, August 2, p. 183.
The **operation of single lines** of railway. — IV. (1 600 words & fig.)

1929 625 .142.4
Railway Gazette, No. 5, August 2, p. 186.
EMPERGER (F. V.). — New type of **concrete steel sleepers.** (800 words & fig.)

1929 656 .225 (.42) & 656 .261 (.42)
Railway Gazette, No. 5, August 2, p. 188.
**Container traffic,** railhead distribution and road transport on the Great Western Railway. (1 200 words & fig.)

1929 656 .1 (.42)
Railway Gazette, No. 5, August 2, p. 190.
**Road motor developments** on the Great Western Railway. (900 words.)

1929 625 .245 (.42)
Railway Gazette, No. 6, August 9, p. 222.
New **steel vans** for conveying grain in bulk, London Midland & Scottish Railway. (800 words & fig.)

1929 725 .33 (.54)
Railway Gazette, No. 6, August 9, p. 224.
New **workshops** at Ratmalana, Ceylon Government Railway. (2 100 words & fig.)

1929 656 .255 (.42)
Railway Gazette, No. 6, August 9, p. 227.
The **operation of single lines** of railway. — V. (2 600 words.)

1929 621 .133.7
Railway Gazette, No. 6, August 9, p. 230.
The A. C. F. I. (Auxiliaire des chemins de fer et de l'industrie) **feed-water heater.** (300 words & fig.)

1929 625 .235
Railway Gazette, No. 6, August 9, p. 232.
**Passenger safety** on railways. (700 words & fig

1929 656
Railway Gazette, No. 7, August 16, p. 248.
The outer **home signal** and other matters. ( words.)

1929 625 .231
Railway Gazette, No. 7, August 16, p. 249.
**Railway compartment** prize designs. (500 wor fig.)

1929 621 .335 (.82) & 621 .4
Railway Gazette, No. 7, August 16, p. 255.
Successful **Diesel-electric locomotive** tests in S America. (1 200 words & fig.)

1929 656 .213
Railway Gazette, No. 7, August 16, p. 256.
ROSS-JOHNSON (D.). — The **relation between ways and ports** under the Railways Act. (2 200 wo

1929 656 .255
Railway Gazette, No. 7, August 16, p. 258.
The **operation of single lines** of railway. — VI. ( words.)

1929 625 .232
Railway Gazette, No. 7, August 16, p. 261.
New **passenger rolling-stock** for Tanganyika ways. (1 400 words & fig.)

1929 659
Railway Gazette, No. 7, August 16, p. 262.
Indian State Railways **publicity.** (1 400 words &

1929 725 .31
Railway Gazette, No. 8, August 23, p. 287.
Remodelling of Victoria Terminus (Bombay), Indian Peninsula Railway. (1 400 words.)

1929 656 .255
Railway Gazette, No. 8, August 23, p. 288.
The **operation of single lines** of railway. — (3 000 words.)

1929 621 .132.5
Railway Gazette, No. 8, August 23, p. 291.
**2-8-2 locomotives,** Buenos Ayres & Pacific Rail (700 words & fig.)

1929 656 .215
Railway Gazette, No. 8, August 23, p. 292.
**Lighting by paraffin vapour lamps.** (400 wor fig.)

1929 656 .255
Railway Gazette, No. 9, August 30, p. 315.
The **operation of single lines** of railway. — (1 600 words.)

1929 656 .222.5
Railway Gazette, No. 9, August 30, p. 316.
A novel **graphic suburban time-table.** (900 wor fig.)

1929 656 .26 (.42)
Railway Gazette, No. 9, August 30, p. 322.
**Double-deck cattle wagons for the London & North Eastern Railway.** (1 100 words & fig.)

1929 656 .26 (.42)
Railway Gazette, No. 9, August 30, p. 325.
**Goods containers** on railways. (600 words & fig.)

1929 656 .235.3 (.42)
Railway Gazette, No. 10, September 6, p. 348.
**Railway companies' dock-charging powers.** (1 900 words.)

1929 656 .253 (.54)
Railway Gazette, No. 10, September 6, p. 353.
COX (H. E.). — **Colour light automatic signals** on the Great Indian Peninsula Railway. (3 700 words & fig.)

1929 656 .255 (.42)
Railway Gazette, No. 10, September 6, p. 362.
The **operation of single lines** of railway. — IX. (1 500 words.)

1929 656 .222 (.42)
Railway Gazette, No. 10, September 6, p. 363.
**Graphic train service records.** (700 words & fig.)

## Railway Magazine. (London.)

1929 656 .222.1 (.42)
Railway Magazine, September, p. 187.
ALLEN (C. J.). — **British locomotive practice and performance.** (5 100 words & fig.)

## Railway Mechanical Engineer. (New York.)

1929 625 .234 (.71)
Railway Mechanical Engineer, August, p. 472.
**Passenger car heating and plumbing.** (2 300 words & fig.)

1929 621 .132.1 (.71 + .73)
Railway Mechanical Engineer, August, p. 477.
Examples of recent **freight locomotives** of the 2-10-0, 2-10-2 and 2-10-4 types. (1 table.)

1929 621 .138.5 (.71) & 625 .26 (.71)
Railway Mechanical Engineer, August, p. 478.
**Canadian National maintenance regulations effective.** (700 words & fig.)

1929 621 .135.3 (.73) & 625 .213 (.73)
Railway Mechanical Engineer, August, p. 483.
**Driving wheel springs and equipment for spring repairs.** (4 600 words, 2 tables & fig. )

1929 656 .222.6 (.73)
Railway Mechanical Engineer, August, p. 490.
**Refrigerated transport** discussed at Pennsylvania State. (3 600 words.)

1929 621 .138.5 (.73) & 669 .1 (.73)
Railway Mechanical Engineer, August, p. 494.
**How the Missouri Pacific handles alloy steel.** (2 500 words & fig.)

1929 621 .132.5 (.73)
Railway Mechanical Engineer, August, p. 500.
RIEGEL (S. S.). — **4-8-4 type locomotives** for the Lackawanna. (1 200 words, 1 table & fig.)

## Railway Signaling. (Chicago.)

1929 656 .256.3 (.73)
Railway Signaling, August, p. 281.
**Automatic signaling** in the New Cascade tunnel. (3 000 words & fig.)

1929 656 .254 (.73) & 656 .255 (.73)
Railway Signaling, August, p. 286.
WESTBAY (J. H.). — Big Four improves operation by **remote control of switches and signals.** (3 600 words & fig.)

1929 656 .28 (.73)
Railway Signaling, August, p. 289.
FRANKLIN (H. A.). — Iowa Commission summarizes **crossing accident statistics.** (700 words & 2 tables.)

1929 656 .253 (.73)
Railway Signaling, August, p. 291.
SAUNDERS (J. E.). — **Signal system for automatic train control.** (4 200 words & fig.)

1929 656 .257 (.73)
Railway Signaling, August, p. 295.
The Chicago and Alton installs **mechanical plant.** (1 500 words & fig.)

1929 656 .25 (.492)
Railway Signaling, August, p. 297.
**Institution of Signal Engineers meets in Holland.** (1 700 words & fig.)

1929 656 .253 (.73)
Railway Signaling, August, p. 299.
Optical features of German **train control** reflect ingenuity. (3 400 words & fig.)

1929 625 .162 (.73) & 656 .259 (.73)
Railway Signaling, August, p. 303.
North Shore Line installs **automatic highway crossing gates.** (1 000 words & fig.)

### In Spanish.

## Gaceta de los Caminos de hierro. (Madrid.)

1929 656 .212 (.73)
Gac. de los Cam. de hierro, nº 3593, 10 de Agosto, p. 265.
La nueva **estación de clasificación** de Portsmouth. (1 600 palabras & fig.)

## In Italian.

### Annali dei lavori pubblici. (Roma.)

1929 624 .6

Annali dei lavori pubblici, giugno, p. 498.

BELLUZZI (O.). — **Sul comportamento degli archi elastici molto ribassati.** (9 300 parole & fig.)

### Rivista tecnica delle ferrovie italiane. (Roma.)

1929 621 .133.7 (.45)

Rivista tecnica delle ferrovie ital., n° 1, 15 luglio, p. 1.

MICHELUCCI (A.). — **Impianti di depurazione chimica dell'acqua per l'alimentazione delle locomotive sulla rete delle Ferrovie dello Stato.** (10 200 parole & fig.)

1929 625 .251

Rivista tecnica delle ferrovie ital., n° 1, 15 luglio, p. 38.

CORBELLINI (G.). — **Nuovi abachi di frenatura dei treni.** (Continuazione e fine.) (2 700 parole, 2 quadri & fig.)

## In Dutch.

### De Ingenieur. (Den Haag.)

1929 656 .253

De Ingenieur, Nr 32, 10 Augustus, p. 67.

DE VOS VAN NEDERVEEN CAPPEL (G. J.). — **Beteekenis en benaming der seinpalen.** (10 700 woorden & fig.)

1929 624 .2

De Ingenieur, Nr 34, 24 Augustus, p. 212.

MULLER (J.). — **Iets over maximum momenten in spoorwegbruggen door laststelsels en hun aequivalente gelijkmatig verdeelde belastingen.** (2 100 woorden & fig.)

### De Locomotief. (Amsterdam.)

1929 625 .62 (.45)

De Locomotief, Nr 32, 7 Augustus, p. 249.

**Nieuwe motorwagens der Tramwegmaatschappij Milaan-Gallarate.** (2 900 woorden & fig.)

### Spoor- en Tramwegen. (Utrecht.)

1929 656 .222 (.492)

Spoor- en Tramwegen, Nr 3, 6 Augustus, p. 54.

KLEYN (F. J.). — **De dienstregeling der locomotieven en van het locomotiefpersoneel der Nederlandsche Spoorwegen.** (3 700 woorden & fig.)

1929 656 .1 (.92) & 656 .2 (

Spoor- en Tramwegen, Nr 3, 6 Augustus, p. 57.

WEITZENBÖCK (R. M.). — **Steenen of ijzeren w voor Sumatra?** (Slot.) (4 900 woorden & fig.)

1929 656 .2

Spoor- en Tramwegen, Nr 4, 20 Augustus, p. 78.

JAGT (A. G.). — **Vervoer van losgestort graa spoorwegwagens.** (3 300 woorden & fig.)

1929 621 .132.3 (.4

Spoor- en Tramwegen, Nr 4, 20 Augustus, p. 93.

**1-D-2 sneltreinlocomotief** voor de Oostenrijksche I desbahnen. (800 woorden & fig.)

## In Polish.

### INŻYNIER KOLEJOWY. (Warszawa.)

1929 385 .4 (.4

Inzynier Kolejowy, 1 Sierpnia, stron 233.

SZTOLCMAN (S.). — Organizacja Centralnego zadu Kolejowego w Polsce. (3 300 slowa.)

1929 621 .1

Inzynier Kolejowy, 1 Sierpnia, stron 240.

FELSZ (S.). — Szkice z gospodarki cieplnej na p wozach. (1 700 slowa.)

## In Portuguese.

### Boletim do Instituto de Engenharia. (S. Paulo.) (Brasil.)

1929 62. (01 &

Boletim do Instituto de Engenharia, Junho, p. 263.

TORRES (A. F.). — **Determinaçâo dos limites de e ticidade dos metaes.** (8 700 palavras & fig.)

### Revista das Estradas de Ferro. (Rio de Janeir

1929 385. (87.3 (

Revista das Estradas de ferro, n° 97, 30 de Julho, p.

MONTEIRO FILHO (J.). — **Realizações que surg — O ensino profissional na Central do Brasil.** (2 palavras & fig.)

# MONTHLY BIBLIOGRAPHY OF RAILWAYS [1]

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## I. — BOOKS.

### In French.

1929 665 .882

RANJON (R.) & ROSEMBERG (P.).

Manuel pratique de soudure autogène.

Paris (6e), Dunod, 92, rue Bonaparte. Un volume 13 × 21 cm.), 410 pages. (Prix : 28 francs.)

1929 621 .392

OEHN (E.).

Renforcement des soudures couvre-joints, discontinus, udés.

Paris (6e), Ch. Béranger, 15, rue des Saints-Pères. n volume in-8° (14 × 22 cm.) de 103 pages, avec 9 figures et 7 tableaux. (Prix : 20 francs.)

1929 721 .1

Les fondations en terrain compressible.

Paris, Société des pieux Franki, rue de Clichy, 54. ne brochure (22 × 25 cm.) de 136 pages & 170 fi- ires.

1929 691

ALETTE (J.).

Les défauts des mortiers et des bétons.

Paris (6e), Dunod, rue Bonaparte, 92. Volume 6 × 25 cm.), 226 pages et 49 figures. (Prix : francs.)

1929 62. (01 & 669

EGNAULD (Paul), ingénieur en chef de l'artillerie navale.

Déformations permanentes et ruptures des aciers.

Paris (6e), Dunod, 92, rue Bonaparte. Un volume 6 × 25 cm.), 92 pages et 31 figures. (Prix : francs.)

### In German.

1929 721 .9

EDLER v. EMPERGER (F.).

Handbuch für Eisenbetonbau.

Leipzig. Verlag von Johann Ambrosius Barth. 192 S. mit Abb. (Preis : 6.80 Rm.)

1929 385 .1 (.73)

HOMBERGER (Ludwig), Dr.

Wirtschaftsführung und Finanzwesen bei amerikanischen Eisenbahnen.

Berlin, Verkehrswissenschaftliche Lehrmittelgesellschaft bei der Deutschen Reichsbahn. 103 Seiten.

1929 656 .256

HÜBENER (E.), Reichsbahninspektor in Goslar.

Unregelmässigkeiten im Blockdienst und besondere Vorkommnisse im Betrieb.

Im Selbstverlag des Herausgebers. 63 Seiten. (Preis: 1.50 Rm.)

1929 691

KLEINLOGEL (A.). Unter Mitarbeit von F. HUNDESHAGEN und O. GRAF.

Einflüsse auf Beton. Die chemichen, mechanichen u. sonst. Einflüsse von Luft, Wasser, Säuren, Laugen, Oelen, Dämpfen, Erden, Lagergütern u. dergl. auf Zement, Mörtel, Beton u. Eisenbeton sowie d. Massnahmen zur Verringerung u. Verhütung diser Einflüsse. 3. neubearbeitete u. bedeutend erweiterte Auflage.

Leipzig. Verlag von Johann Ambrosius Barth. 97-192 S. mit Abb. (Preis : 6 Rm.)

1929 625 .246

LEHNER (F.).

Der neuzeitliche Waggonbau von der Vorberechnung bis zur Inbetriebnahme.

Leipzig. Verlag von Johann Ambrosius Barth. 614 S. mit 13 Taf. und 352 Abb. (Preis : 25 Rm.)

[1] The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly th the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to Railway Science », by Weissenbruch in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509).

1929 621 .43

**LOMONOSSOFF (G.),** Dr.-Ingenieur.

**Diesel-Lokomotiven.**

Berlin, V. D. I. Verlag. 302 Seiten, 401 Abbildungen & 3 Tafeln.

1929 621 .137

**MAEY (H.) & KOEPPE (E.).**

**Merkbuch für Werkstudenten und Reichsbahnbauführer im Lokomotivfahrdienst.**

Darmstadt, Verkehrszentralamt der Deutschen Studentenschaft, Technische Hochschule. (Preis : 2.50 Rm.)

1929 656

**NAGEL,** Reichsbahnoberrat.

Fragelbuch zu Heinrich, **Eisenbahnbetriebslehre.** Teil I.

Berlin, Verkehrswissenschaftliche Lehrmittelgesellschaft bei der Deutschen Reichsbahn. 173 Seiten. (Preis: 4.50 Rm.)

1929 621 .43

**NEUMANN (K.) & KLUSENER (O.).**

Untersuchungen an der **Dieselmaschine.**

Berlin, V. D. I. Verlag. 35 Seiten mit 64 Abbildungen und 6 Zahlentafeln. (Preis : 6 Rm.)

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**QUAATZ (R. G.),** Dr.

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1929 385 (.43)

**Reichsbahn-Handbuch 1929.**

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**SAURAU (F. X.),** Ingenieur.

**Die Entwicklung der elektrischen Lokomotiven und Triebwagen, unter besonderer Berücksichtigung Österreichs.**

Wien, Buchverlag Vienna Rudolf Jamnig. 1 Tabelle und 78 Abbildungen. (Preis : 4.60 Rm.)

1929 621 .335 (.09)

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**Fünfzig Jahre elektrische Lokomotive.**

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1929 656 .28 (01 (.42)

**Accidents.** Report of Minister of Transport for 1928.

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1929 721

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The ideals of **engineering architecture.**

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1929 65

**LOREE (L. F.).**

Recent changes in **railway economics.**

New York City, Delaware & Hudson Co. 25 page

1929 016 .5 & 01

**MASSACHUSETTS INSTITUTE OF TECHNOLO**

**Abstracts of scientific and technical publications f** the Massachusetts Institute of technology.

Cambridge (Massachusetts), the Technology P 75 pages and 15 tables.

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1929 385 .11 (

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1929 385 .587, 621 .138.5 & 625

**SAUNDERS (H. H.),** M. B. E., A. M. I. Mech. E.

A schedule system for the **control of operation workshops.**

Calcutta. Government of India. Central Publica Branch. 23 pages and 7 appendices.

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**WAGSTAFF (H. W.),** Major, M. C., R. E.

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1929 385. (02 (.

**DE LA TORRE (Enrique).**

**Anuario de Ferrocarriles y Tranvias.**

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1929 385 (.

**STOCKHUIZEN (W. A. F.),** Dr.

**Spoorwegpolitiek** in Nederland.

Roermond. J. J. Romen en Zoon. 134 bladzijden.

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### Annales des Mines. (Paris.)

1929 536

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SOCHACZEWER (D.). — Note sur les connaissances tuelles des propriétés de la **vapeur d'eau**. (Suite et n.) (5 900 mots, 8 tables & fig.)

### Annales des Ponts et Chaussées. (Paris.)

1929 691

nnales des Ponts et Chaussées, mai-juin, p. 259.

LAMORRE. — Note au sujet de quelques particula- tés du **béton armé**. (4 800 mots & fig.)

### Bulletin de l'Association internationale permanente des Congrès de la route. (Paris.)

1929 656 (.6)

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JEFFREYS (R.). — Du Cap au Caire. — **Le pro- lème des routes et des transports dans le Sud et l'Est e l'Afrique.** (2 300 mots.)

### Bulletin de l'Union internationale des chemins de fer. (Paris.)

1929 385. (09 (.44)

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**Le réseau de Paris-Lyon-Méditerranée de 1924 à 1928.** — Extrait du rapport présenté par le Conseil d'Admi- istration à l'Assemblée générale des actionnaires du 5 avril 1929. (Suite et fin.) (12 000 mots.)

1929 385 .113 (.498)

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CODREANO (N.). — **Les principaux résultats de exploitation des chemins de fer de l'Etat roumain en 928.** (1 300 mots, 8 tableaux & fig.)

1929 625 .1 (.44 + .460)

ull. de l'Union intern. des ch. de fer, juill.-août, p. 230.

**Une nouvelle ligne à travers les Pyrénées.** (1 000 mots, carte & fig.)

1929 385 .113 (.43)

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**Rapport du Commissaire des chemins de fer allemands ur le quatrième exercice de fonctionnement de la Com- agnie** (1er janvier-31 décembre 1928). (A suivre.) 29 000 mots.)

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**Statistique des chemins de fer royaux de l'Etat hon- grois pour l'année 1925-26.** (1 800 mots.)

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HALCROW (W. T.), BROOK (G. B.) & PRESTON (R.). — **L'action corrosive des eaux tourbeuses sur les bétons.** (Suite et fin.) (3 600 mots & fig.)

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Bull. techn. de la Suisse rom., n° 19, 21 sept., p. 217.

LEYVRAZ (L. H.). — **La ligne de contact du chemin** de fer Viège-Zermatt. (A suivre.) (2 800 mots & fig.)

### Chronique des transports. (Paris.)

1929 656 .1

Chronique des transports, n° 16, 25 août, p. 3.

Le développement des **transports par route** dans le monde. (2 100 mots.)

1929 385 .113 (.43)

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**Le neuvième rapport du Commissaire des chemins de fer allemands.** (2 000 mots.)

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**Pont en arc de 504 mètres sur le Kill van Kull près** de New-York. (2 200 mots & fig.)

1929 62. (01

Génie civil, n° 2455, 31 août, p. 197.

TOURNAYRE (L.). — **Note sur le flambement des arcs surbaissés.** (Suite et fin.) (4 200 mots & fig.)

1929 621 .135.4

Génie civil, n° 2456, 7 septembre, p. 231.

Les **bogies à deux essieux** pour locomotives. (1 500 mots & fig.)

1929 627 (.492)

Génie civil, n° 2456, 7 septembre, p. 228.

BYLS (A.). — **Les travaux d'extension du port de Flessingue.** (1 700 mots & fig.)

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BRYLA (S.). — Le pont-route métallique, soudé à l'arc électrique, de Lowicz (Pologne). (4 200 mots & fig.)

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BODET (J.). — Comment on a édifié la nouvelle gare de Limoges, l'une des plus belles de France. (2 300 mots & fig.)

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Les chemins de fer et les tramways, août, p. 156.
**Locomotive Decapod à 3 cylindres, de la Compagnie des chemins de fer de l'Est.** (2 700 mots & fig.)

1929 621 .33
Les chemins de fer et les tramways, août, p. 158.
**L'électrification des chemins de fer.** (6 600 mots.)

1929 691
Les chemins de fer et les tramways, août, p. 163.
CROZET (A.). — **Les chapes souples.** (1 600 mots & fig.)

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1929 656 .1 (.73) & 656 .2 (.73)
L'Ind. voies ferrées et transp. autom., sept., p. 344.
L'évolution de l'industrie des transports en commun aux Etats-Unis au cours de l'année 1928. (6 000 mots & fig.)

1929 625 .62
L'Ind. voies ferrées et transp. autom., sept., p. 356.
VENTE. — **Progrès réalisés dans le freinage des tramways. — Rapport présenté au XXI[e] Congrès international (Rome, 6-12 mai 1928). (Suite.)** (5 700 mots & fig.)

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LOISEAU (Ch.). — **Le développement des services internationaux de wagons-lits depuis la guerre.** (7 900 mots.)

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BLONDEL. — **Note au sujet des travaux d'agrandissement de la gare de Paris-Austerlitz.** (4 600 mots & fig.)

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VALLANCIEN. — **Unification du matériel ro de petite vitesse des grands réseaux français.** ( mots.)

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**Résultats obtenus en 1928 sur les réseaux des compagnies principales des chemins de fer fran** (7 tableaux.)

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1929 624
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**Mise en place ou enlèvement rapide des tabliers liaires employés par la Compagnie Paris-Lyon-Méd ranée.** (250 mots & fig.)

1929 625 .232
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**Voiture à bogies agencée pour le transport d'enf malades, sur le réseau Paris-Lyon-Méditerranée.** ( mots & fig.)

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HACHA (L.). — **La fabrication des rails en Thomas.** (5 400 mots & fig.)

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BARBILLION (L.). — **L'électrification des che de fer de banlieue et des lignes de rabattement.** suivre.) (800 mots & fig.)

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RIHOSEK (J.). — **Le développement technique freinage continu des longs trains de marchand** (A suivre.) (2 400 mots & fig.)

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1929 385. (09 (.81)
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STINNER. — **Brasilianische Centralbahn.** (10 500 Vörter, 1 Karte & Abb.)

1929 656 .23 (.494)
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MIESCHER (O.). — Die **finanziellen Ursachen der** ohen **schweizerischen Eisenbahntarife.** (7 500 Wörter.)

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KELLER (E.). — Die verkehrsgeographischen Grundgen der deutschen **Eisenbahnumwege** mit besonderer erücksichtigung von Nord- und Mitteldeutschland. Schluss.) (18 000 Wörter & 1 Tafel.)

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DIECKMANN. — Die **Eisenbahnen in Irak.** (9 200 Vörter & 2 Karten.)

1929 385. (09 (.51)
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CREMER (M.). — Die **Ostchinesische Bahn.** — Der eil der Transsibirischen Bahn von Mandschurei bis uantschentzy. (4 600 Wörter.)

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Die **Deutsche Reichsbahn** im Geschäftsjahr 1927. 200 Wörter.)

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Die **italienischen Staatsbahnen** im Rechnungsjahr 26-1927. (5 000 Wörter.)

1929 385 .113 (.489)
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GIESE (F.) & HEYLAND (C.). — Die Sonderanrüche der während des **Ruhrkampfes** ausgewiesenen utschen **Reichsbahnbediensteten.** (1 800 Wörter.)

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KUHATSCHECK (O.). — Die **Kranken- und Arbeirpensionskassen,** die **Angestellten-, Unfall- und beitslosenversicherung** bei der Deutschen Reichsbahn Jahr 1928. (13 100 Wörter.)

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Die Entwicklung der **lettischen Eisenbahnen.** (5 500 Wörter.)

1929 385 .113 (.485)
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Das **schwedische Eisenbahnnetz** 1926 und 1927. (2 800 Wörter.)

1929 385 .113 (.481)
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RAJZ (K.). — Die **Königlich ungarischen Staatsbahnen** im Betriebsjahr 1926-1927. (3 700 Wörter.)

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Die **rumänischen Staatsbahnen** im Jahr 1926. (3 300 Wörter.)

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Die **Betriebsergebnisse** der fünf grossen **französischen** Eisenbahngesellschaften im Jahr 1927. (2 600 Wörter.)

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**Brown-Boveri-Bahnmaterial.** (900 Wörter & Abb.)

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**Internationale Elektrotechnische Kommission.** Sitzungen in London, Juli 1929. (5 700 Wörter.)

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Neue Reibungsmessungen an Schweizer **Vollbahnlokomotiven.** (250 Wörter & Abb.)

## Glasers Annalen. (Berlin.)

1929 621 .132.8 & 621 .43
Glasers Annalen, Heft 4, 15. August, S. 57.
MANGOLD (G.). — **Personenzug-Diesellokomotive** 2-4-2 für das russische Profil. (Schluss.) (4 300 Wörter, 3 Tafeln & Abb.)

1929 656 .212.8
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RAUDNITZ (M.). — Die **Prüfung von Gleiswaagen** über 50 t, Wiegefähigkeit auf Brückendurchbiegung. (4 600 Wörter, 13 Tafeln & Abb.)

1929 624 .2
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LOMONOSSOFF (G.). — Ueber den **dynamischen Druck der Lokomotivräder.** (4 900 Wörter & Abb.)

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SMITH (C. E.). — **Co-ordination of community transportation.** (3 500 words & fig.)

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BUCK (M.). — **Fares** should be put on a more scientific basis. (4 400 words & fig.)

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HALLIHAN (J. P.). — Relation of **rapid transit** to community development. (7 000 words & fig.)

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FAUST (C. A.). — New objectives govern **vehicle design.** (3 300 words & fig.)

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THOMAS (D. R.). — Attracting new **freight business.** — Fundamental problem of interurbans. (4 300 words & fig.)

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1929 625 .13 (
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STABLER (C. I.). — **Reconstructing a rail bridge** in India. (4 000 words & fig.)

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The Ljungström non-condensing **turbine locomot**
(700 words.)

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**Single lines of railway.** (1 600 words.)

1929 656 .255 (.
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The Mumbles Railway and its **signalling.** (2
words.)

1929 625 .1 (.
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**Improvements** at Frodingham (London and No
Eastern Railway). (3 000 words & fig.)

1929 625 .4 (.
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BENNIE (G.). — **The « railplane » car and overh**
**construction.** (600 words & fig.)

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Engineer, No. 3842, August 30, p. 217.
**A new Transpyrenean Railway.** (2 600 words & f

1929 621
Engineer, No. 3842, August 30, p. 227.
The **electrification of railways.** (1 600 words.)

1929 625 .245 (.
Engineer, No. 3842, August 30, p. 230.
An American **dynamometer car.** (3 600 words & f

1929 624 .8 (.9
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New **road and rail bridge** in New South Wales. (
words & fig.)

1929 669
The Metallurgist, p. 115. Supplement to the Engin
August, 1929.
O'NEILL (H.). — **Hardness features in « Widia**
**and manganese steel.** (1 300 words, 4 tables & fig.)

1929 62. (01 & 669
The Metallurgist, p. 118. Supplement to the Engin
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HATFIELD (W. H.). — **Permanence of dimensi**
**under stress.** (1 400 words & fig.)

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August, 1929.
The **strength of wire ropes.** (1 300 words.)

1929 669 .1
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**Age-hardening in mild steel.** (1 500 words.)

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The Metallurgist, p. 124. Supplement to the Engineer, August, 1929.
**The work of rupture in relation to fatigue.** (500 words.)

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BRYLA (S.). — **The first arc-welded bridge in Europe.** (1 900 words & fig.)

1929 621 .132.4 (.54)
Engineer, No. 3844, September 13, p. 284.
Bengal-Nagpur Railway. — **Four-cylinder compound locomotives.** (900 words & fig.)

1929 621 .116 & 669 .1
The Metallurgist, p. 131. Supplement to the Engineer, September 27, 1929.
**Cracking of boiler plates.** (1 100 words & fig.)

1929 62. (01
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**The strength and testing of materials.** (1 800 words.)

1929 624 .0 & 669 .1
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**Structural manganese steel.** (900 words.)

1929 62. (01 & 669 .1
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**A new macroscopic etching reagent.** (1 100 words.)

## Engineering. (London.)

1929 656 .212.6 (.71)
Engineering, No. 3317, August 9, p. 163.
**Unloading machine for grain cars.** (2 900 words.)

1929 625 .122
Engineering, No. 3317, August 9, p. 185.
**Half cubic-yard excavator with chain track.** (2 000 words & fig.)

1929 691 (.71)
Engineering, No. 3318, August 16, p. 189.
**The Canadian specification for concrete and reinforced concrete.** (3 300 words & fig.)

1929 621 .13 (0 (.68)
Engineering, No. 3319, August 23, p. 229.
LOUBSER (M.). — **Mechanical engineering problems of the 3-ft. 6-in. gauge, South African Railways.** (5 000 words.)

1929 656 .212.7 (.71)
Engineering, No. 3320, August 30, p. 257.
**Unloading machine for grain cars.** (2 200 words & fig.)

1929 621 .116 (.42)
Engineering, No. 3320, August 30, p. 275.
**Feed-water de-aerator.** (900 words.)

1929 624 .62 (.73)
Engineering, No. 3321, September 6, p. 281.
**Full-scale and Beggs deformeter tests on a reinforced concrete arch bridge.** (To be continued.) (4 200 words & fig.)

1929 313 : 656 .28 (.42)
Engineering, No. 3321, September 6, p. 296.
**Accidents on British railways.** (1 300 words.)

1929 691 (.73)
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**Experience with concrete and concrete structures in the United States.** (2 800 words.)

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RUSSELL (Th. F.). — **Low-expansion nickel steel.** (4 800 words, 2 tables & fig.)

1929 385 (.09.3 (.51)
Engineering, No. 3324, September 27, p. 402.
STRINGER (H.). — **The Peipiao extension of the Chao Yang branch of the Peking-Mukden Railway.** (To be continued.) (3 900 words, 2 tables & fig.)

## Engineering News-Record. (New York.)

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HUNLEY (J. B.). — **Bridge of unusual design replaces Ohio river crossing of Big Four at Louisville.** (4 000 words & fig.)

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MAY (J. O.). — **Unique crane loads freight cars on ship for Ocean transport.** (3 200 words & fig.)

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Engineernig News-Record, No. 10, September 5, p. 373.
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Santa Fe gondola has cast steel underframe. (1 words & fig.)

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**Maintenance tests** at Burlington **interlocker.** (1 300 ords & fig.)

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Chicago & North Western employs **centralized control speed up trains.** (3 400 words & fig.)

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**Situación financiera** de los Ferrocarriles del Reich en 928. (Continuarà.) (3 000 palabras.)

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MENDIZABAL (D.). — Los **tramos metálicos** de sia. (2 000 palabras & fig.)

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DINO LEVI DE VEALI. — Il **nuovo viadotto** sulla Valle Olona per la linea Milano-Varese delle Ferrovie Nord-Milano. (18 400 parole, 9 quadri & fig.)

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OTTONE (G.). — **I rapporti fra lo stato e le ferrovie concesse.** (8 000 parole.)

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**Samenwerking tusschen spoorwegen en autobussen in Zwitserland.** (2 600 woorden.)

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LAMAN TRIP (G. J.). — **Het spoorwegstation Parijs-Oost.** (Wordt vervolgd.) (3 600 woorden & fig.)

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# MONTHLY BIBLIOGRAPHY OF RAILWAYS [1]

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[ 016 .385 (02 ]

## I. — BOOKS.

### In French.

1929 669

USQUET (C.).

La fabrication de la fonte malléable.

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1929 385 .5

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Transport co-ordination. A study of present-day transport problems.

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**Trains of to-morrow.**

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TETTELIN. — Note sur une **substitution de voies principales avec engins mécaniques.** (4 300 mots et fig.)

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LEFÈVRE. — **Block automatique de voie unique** sur le réseau Paris-Orléans. (3 200 mots et fig.)

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**1929** 625 .251

Rev. univer. des transp. et des commun., n° 104c, p. 193.

RIHOSEK (J.). — Le développement technique du **freinage continu des longs trains de marchandises.** (suite). (1 600 mots et fig.)

**1929** 656 (.44)

Rev. univer. des transp. et des commun., n° 104c. p. 201.

RÉMONI (G.). — Quelques-unes des améliorations apportées dans **l'exploitation des chemins de fer de** Paris à Lyon et à la Méditerranée (1924-1928). (2 300 mots.)

# In German.

## Elektrische Bahnen. (Berlin.)

**1929** 621 .33 (.494)

Elektrische Bahnen, September, S. 265.

SCHULER (H. W.). — **Der elektrische Betrieb** der Schweizerischen Bundesbahnen, Ende 1928. (2 100 Wörter.)

**1929** 621 .335

Elektrische Bahnen, September, S. 268.

DRESCHER (H.). — Beitrag zur Frage der **Anfahrmöglichkeit von elektrischen Lokomotiven** mit angehängter Zuglast. (Schluss.) (2 900 Wörter & Abb.)

**1929** 621 .335 (.73)

Elektrische Bahnen, September, S. 284.

NORDEN. — **Amerikanische elektrische Lokomotiven.** (2 800 Wörter & Abb.)

**1929** 621 .33 (.92)

Elektrische Bahnen, September, S. 289.

HUG (A. M.). — **Die Elektrisierung** der Niederländisch-Indischen Staatsbahnen auf Java. (Schluss folgt.) (3 700 Wörter & Abb.)

## Elektrotechnische Zeitschrift. (Berlin.)

**1929** 537 .4

Elekrotechn. Zeitschrift, Heft 41, 10. Oktober, S. 1469.

MATTHIAS (A.). — Der gegenwärtige stand der **Blitzschutzfrage.** (6 200 Wörter & Abb.)

## Glasers Annalen. (Berlin.)

**1929** 621 .135. (01

Glasers Annalen, Heft 6, 15. September, S. 92.

LOMONOSSOFF (G.). — Ueber den **Dynamischen Druck** der Lokomotivräder. (3 800 Wörter & Abb.)

**1929** 656 .224

Glasers Annalen, Heft 6, 15. September, S. 98;
Glasers Annalen, Heft 7, 1. Oktober, S. 111.

SCHWAIGHOFER (H.).— **Gliederbänder und Ketten-Standbahnen** in der Postfördertechnik. (5 000 Wörter & Abb.)

**1929** 621 .138.3

Glasers Annalen, Heft 7, 1. Oktober, S. 114.

SCHEIER. — Schlackenverladung. — Verwendung von ein- und doppelseitigen Schrägaufzügen zur Verladung von Lokomotivschlacken. (900 Wörter & Abb.)

## In English.

### Electric Railway Journal. (New York.)

1929 621 .33 (06 (08 (.73)
Electric Railway Journal, October, p. 951.
**Proceedings of the 48th Annual Convention of the American Electric Railway Association.** (38 000 words & fig.)

1929 388 (.73)
Electric Railway Journal, November, p. 1033.
**Survey shows transit trends in 23 cities.** (5 300 words.)

1929 621 .338 (.73)
Electric Railway Journal, November, p. 1037.
Lightness and speed mark new car **designs.** (3 800 words & fig.)

1929 385 .51 (.73)
Electric Railway Journal, November, p. 1043.
VICKERS (L.). — **Local transportation** improving its industrial relations. (2 400 words & fig.)

1929 621 .335 (.73)
Electric Railway Journal, November, p. 1045.
TALIAFERRO (W. R.). — Choosing **electric locomotives** to fit the service. (2 000 words & fig.)

### Engineer. (London.)

1929 621 .89
Engineer, N° 3849, October 18, p. 405.
DEELEY (R. M.). — **Lubrication and lubricants.** (5 400 words.)

1929 536
Engineer, N° 3852, November 8, p. 487.
CALLENDAR (H. L.). — **Critical relations between water and steam.** (4 000 words.)

1929 656
Engineer, N° 3849, November 8, p. 493.
**The development of transport.** (6 200 words.)

### Engineering. (London.)

1929 385. (09 .1 (.51)
Engineering, N° 3325, October 4, p. 427.
STRINGER (H.). — The **Peipiao extension** of the Chao Yang branch of the Peking-Mukden Railway. (3 800 words & fig.)

1929 621 .132 .8 (.42) & 621 .4 (.42)
Engineering, N° 3325, October 4, p. 436.
**Petrol-driven locomotive** for raft transporting wagon. (2 200 words & fig.)

1929 656 .21
Engineering, N° 3325, October 4, p. 442.
**Transport by train ferries.** (2 100 words).

1929
Engineering, N° 3325. October 4, p. 450.
GILKEY (H. J.). — **The tensile autogenous hea of Portland cement mixtures.** (5 100 words.)

1929 624 .63 (
Engineering, N° 3327, October 18, p. 485.
STEINBERG (H. E.). — **Reinforced concrete br** over the Elorn River, Finistère. (2 700 words & fig

1929 38
Engineering, N° 3327, October 18, p. 501.
**Economic investigations on railways.** (2 700 words

1929 624 .2 (
Engineering N° 3327, October 18, p. 506.
**Impact tests** on the Allahabad-Jumna bridge. ( words & fig.)

1929 66
Engineering, N° 3329, November 1, p. 569.
HERBERT (E. G.). — The **hardening of superh dened steel by** magnetism. The lattice-resonance hy thesis. (6 600 words & fig.)

1929 62. (01 & 66
Engineering, N° 3329, November 1, p. 575.
**The hardness of steel balls.** (1 800 words.)

### Engineering News-Record. (New York.)

1929 624 .1 (.
Engineering News-Record, N° 12, September 19, p.
FRANKLIN (Ph. A.). — Tall **bridge pier construct** in an engine roundhouse. (1 200 words & fig.)

1929 691 (.
Engineering News-Record, N° 12, September 19, p.
JOHNSTON (B.). — **Tests on concrete** made at C lidge dam. (1 000 words.)

1929 625 .
Engineering News-Record, N° 12, September 19, p.
**Foreign track-recording** device has special featu (400 words & fig.)

1929 621 .
Engineering News-Record, N° 12, September 19, p.
**Welding Society considers methods of testing.** (4 words & fig.)

1929 624 .51 (.
Engineering News-Record, N° 15, October 10, p. 562
Dismantling two long **suspension bridges.** (6 700 wo & fig.)

1929 625 .13 (.71 + .73)
ngineering News-Record, N° 16, October 17, p. 601.
The Detroit-Canada **vehicular tunnel.** (4 600 words fig.)

-1929 624 .63 (.44)
ngineering News-Record, N° 18, October 31, p. 691.
Unique construction procedure on **long-span concrete ridge arches at Brest,** France. (3 400 words & fig.)

## Locomotive Railway Carriage & Wagon Review. (London).

1929 621 .132 .6 (.436)
oc. Ry. Carriage & Wagon Rev., October 15, p. 313.
**Eight-coupled tank locomotives,** series 423.0, for the zechoslovakian State Railways. (1 400 words & fig.)

1929 621 .133 .5 (.44)
oc. Ry. Carriage & Wagon Rev., October 15, p. 328.
The « K. C. » **blast pipe for locomotives.** (1 200 words fig.)

1929 621 .13 & 621 .43
oc. Ry. Carriage & Wagon Rev., October 15, p. 334.
Economic comparison of the **steam locomotive** with fferent types of **Diesel locomotives.** (1 100 words & g.)

1929 625 .232 (.44)
oc. Ry. Carriage & Wagon Rev., October 15, p. 336.
**Carriages with sleeping accommodation** for excursion ains. (500 words & fig.)

## Mechanical Engineering. (New York.)

1929 621 .18 (.4 + .73)
echanical Engineering, October, p. 727.
HIRSHFELD (C. F.). — Trends in **power-plant de-lopment** in the United States and Europe. (6 200 ords & fig.)

1929 621 .133 .1 (.73)
echanical Engineering, October, p. 765.
**Diesel-fuel-oil specifications.** (4 900 words & fig.)

## Modern Transport. (London.)

1929 656 .212. (.42)
odern Transport, N° 551, October 5, p. 3.
**Freight handling** on the Great Western Railway. 900 words & fig.)

1929 625 .245 (.42)
odern Transport, N° 551, October 5, p. 9.
New London Midland & Scottish Railway rolling ock. (900 words & fig.)

1929 656
Modern Transport, N° 551, October 5, p. 11.
**Transport in all its phases.** (2 400 words & fig.)

1929 735 .31 (.71)
Modern Transport, N° 551, October 5, p. 13.
Proposed **passenger station** for Montreal. (1 000 words & fig.)

1929 656 .1 (.68)
Modern Transport, N° 551, October 5, p. 20.
WHITE (J. D.). — **Road transport** in South Africa. (3 700 words.)

1929 621 .133.7 (.42) & 625 .234 (.42)
Modern Transport, N° 552, October 12, p. 3.
**Water-heating on trains.** — London & North Eastern Railway adopts new methods on locomotives and sleeping cars. (1 300 words & fig.)

1929 385. (08 (.66)
Modern Transport, N° 552, Octobre 12, p. 6.
**Railway progress** in East Africa. (2 800 words & fig.)

1929 621 .132.3 (.71) & 621 .132.5 (.71)
Modern Transport, N° 552, October 12, p. 7.
**Oil-burning locomotives** for Canadian Pacific Railway. (2 000 words & fig.)

1929 385 .0 (.43)
Modern Transport, N° 552, October 12, p. 12.
**Railways in Germany.** — Solution of post-war difficulties. (2 100 words.)

1929 725 .31 (.42)
Modern Transport, N° 552, October 12, p. 13.
Southern Railway **station architecture.** (800 words & fig.)

1929 656
Modern Transport, N° 553, October 19, p. 3.
STAMP (J.). — **Scientific research in transport.** (3 400 words.)

1929 656 .1 & 656 .2
Modern Transport, N° 553, October 19, p. 6.
WILKINSON (H. L.). — **Road transport and the railways.** (3 900 words & fig.)

1929 625 .11 (.460 + .6)
Modern Transport, N° 553, October 19, p. 10.
STRAUSS (F.). — **Tunnelling the strait of Gibraltar.** (4 400 words & fig.)

1929 656 .1 (.42)
Modern Transport, N° 553, October 19, p. 19.
**Road transport** in Great Britain. (2 400 words.)

1929 656 .1 (.42)
Modern Transport, N° 555, November 2, p. 3.
**Regulation of public service vehicles.** (3 200 words.)

1929 621 .392 (.42) & 625 .13 (.42)

Modern Transport, N° 555, November 2, p. 6.

Electric welding for bridges. (1 900 words.)

1929 624 .62 (.42)

Modern Transport, N° 555, November 2, p. 7.

Completion of Wearmouth bridge. (1 800 words.)

1929 385 .113 (.494)

Modern Transport, N° 555, November 2, p. 11.

Development of Swiss Federal Railways. (1 800 words.)

1929 385 .113 (.944)

Modern Transport, N° 555, November 2, p. 12.

New South Wales Railways. — Loss on year's working. (1 600 words.)

1929 625 .1 & 656 .2

Modern Transport, N° 556, November 9, p. 3.

GRIERSON (W. W.). — Railway development and the gauge problem. (3 800 words & fig.)

1929 624 .62

Modern Transport, N° 556, November 9, p. 5.

Characteristics of the steel arch bridge. (1 800 words & fig.)

1929 621 .138 .5, 656 .26 & 657

Modern Transport, N° 556, November 9, p. 13.

NEWTON (C. H.). — Railway workshop costs and accounts. (1 900 words.)

1929 656 .223 .2 (.42)

Modern Transport, N° 556, November 9, p. 14.

Twenty-ton trucks for coal traffic. (3 200 words.)

1929 656 .223 .2 (.42)

Modern Transport, N° 556, November 9, p. 16.

Railway companies and high-capacity wagons. (1 600 words.)

1929 385 .113 (.54)

Modern Transport, N° 556, November 9, p. 17.

Railway progress in India. (1 800 words.)

1929 347 .234 (.42)

Modern Transport, N° 556, November 9, p. 18.

Development of railway transport. — Methods of acquiring land. (2 200 words & fig.)

1929 656 .1 & 656 .2

Modern Transport, N° 556, November 9, Commercial motor exhibit. section, p. IV.

WEDGWOOD (R.). — The railways and the highways. — A review of policy and prospects. (3 200 words & fig.)

## Railway Age. (New York.)

1929 621 .139 (.73), 625 .18 (.73) & 625 .27 (.73)

Railway Age, N° 11, September 14, p. 623.

What's wrong with supply work and what to do about it. (6 300 words & fig.)

1929 656 .212 (

Railway Age, N° 11, September 14, p. 629.

Close supervision solves terminal problem. (2 words & fig.)

1929 625 .232 (

Railway Age, N° 11, September 14, p. 633.

Baltimore and Ohio builds two lounge cars. words & fig.)

1929 656 .25 (06 (08 (

Railway Age, N° 11, September 14, p. 643.

Signal section meets in Atlanta, Ga. (5 400 w & fig.)

1929 656 .212

Railway Age, N° 12, September 21, p. 671.

Taking care of 700 trains a day. (2 500 words, 2 ta & fig.)

1929 621 .132 .8 (.4

Railway Age, N° 12, September 21, p. 674.

Non-condensing turbine locomotives (800 words.)

1929 625 .242 (

Railway Age, N° 12, September 21, p. 675.

Pittsburg & Lake Erie buys 65-ft. gondolas. words & fig.)

1929 625 .1 (06 (08 (

Railway Age, N° 12, September 21, p. 681.

Roadmasters discuss problems of the day. (5 words & fig.)

1929 656 .255 (

Railway Age, N° 13, September 28, section one, p.

FOX (E. N.). — Boston and Maine uses rev traffic signaling in Hoosac Tunnel. (2 600 words &

1929 621 .139 (.73) & 625 .26 (

Railway Age, N° 13, September 28, section one, p.

Railway shop men talk material. (2 200 words &

1929 621 .13 (06 (08 (

Railway Age, N° 13, September 28, section one, p.

DUNN (S. O.) & SILLCOX (L. K.). — Trave engineers' convention. (3 800 words.)

1929 656 .254 (06 (08 (

Railway Age, N° 13, September 28, section one, p.

Telegraph officers discuss problems at St. Paul r ting. (5 200 words & fig.)

1929 625 .1 (06 (08 (

Railway Age, N° 13, September 28, section one, p.

DOWNS (L. A.), FORD (R. H.), BELCHER (R. S. BACKUS (M. M.). — Roadmasters' Association cludes convention. (7 400 words & fig.)

1929 621 .4 (

Railway Age, N° 13, September 28, section one, p.

Hall-Scott 350-Hp. gasoline engines. (1 200 word & fig.)

1929 656 .2 (.73) & 656 .261 (.73)
ailway Age, N° 13, September 28, section two, p. 758.
Railways extend motor coach and truck services. 000 words & fig.)

1929 656 .2 (.73) & 656 .261 (.73)
ailway Age, N° 13, September 28, section two, p. 767.
What does truck operation cost? (1 800 words, 4 ta-es & fig.)

1929 656 .261 (.73)
ailway Age, N° 13, September 28, section two, p. 775.
YOUNG (L. B.). — Store-door service proves success-il. (3 500 words & fig.)

1929 656 .261 (.73)
ailway Age, N° 13, September 28, section two, p. 781.
SCHNEIDER (C. L.). — Lower costs, better service ith trucks and trailers. (1 300 words & fig.)

1929 625 .122 (.73)
ailway Age, N° 14, October 5, p. 807.
Unusual retaining wall proves success on the Pitts-irgh and Lake Erie. (2 100 words & fig.)

1929 621 .13 (06 (08 (.73)
ailway Age, N° 14, October 5, p. 817.
Traveling engineers conclude Chicago meeting. (5 700 ords & fig.)

1929 625 .261 (.73)
ailway Age, N° 14, October 5, p. 822.
The automobile goes to work for the Great Northern. 100 words & fig.)

1929 656 .212 (.73)
ailway Age, N° 15, October 12, p. 853.
Altoona terminal efficiently operated. (2 100 words fig.)

1929 656 .254 (.73 & 656 .255 (.73)
ailway Age, N° 15, October 12, p. 856.
The Denver & Rio Grande Western expedites trains centralized control. (1 700 words & fig.)

1929 656 .25 (06 (08 (.73)
Railway Age, N° 15, October 12, p. 859.
Railroads have largest attendance at safety con-ress. (7 000 words & fig.)

1929 625 .214 (.73)
ailway Age, N° 15, October 12, p. 865.
NYSTROM (K. F.). — Roller-bearing progress repor-d. (3 700 words & fig.)

1929 625 .173 (.73) & 656 .261 (.73)
ailway Age, N° 15, October 12, p. 869.
The automobile goes to work for the Great Northern. 600 words & fig.)

1929 656 .212 .9
ailway Age, N° 16, October 19, p. 903.
Helping agents to help themselves. (2 000 words & g.)

1929 625 .1 (06 (08 (.73)
Railway Age, N° 16, October 19, p. 905.
Bridge and Building Association meets at New Orleans. (7 600 words & fig.)

1929 385 .517 .6 (.73) & 614 .8 (.73)
Railway Age, N° 16, October 19, p. 918.
Safety men discuss use of motor and hand cars. (9 000 words & fig.)

1929 625 .216
Railway Age, N° 16, October 19, p. 925.
ENDSLEY (L. E.). — Some factors in the freight-car draft-car problem. (3 500 words.)

1929 725 .33 (.73)
Railway Age, N° 17, October 26, section one, p. 956.
Small engine terminals can be modern. (3 800 words & fig.)

1929 656 .255 (.71)
Railway Age, N° 17, October 26, section one, p. 962.
Canadian Pacific installs centralized traffic control to solve operating problem. (1 300 words & fig.)

1929 656 .284 (.73)
Railway Age, N° 17, October 26, section one, p. 965.
Railway Fire Association meets at Toronto. (2 900 words & fig.)

1929 656 .223 .2 (.73)
Railway Age, N° 17, October 26, section one, p. 969.
GORMLEY (J.). — Capacity utilization of railroad equipment. (4 700 words & 3 tables.)

1929 621 .4 (.73)
Railway Age, N° 17, October 26, section one, p. 973.
Brill builds large rail-car power plants. (3 200 words & fig.)

1929 625 .27 (.73)
Railway Age, N° 17, October 26, section one, p. 977.
STUART (J. G.). — The railroads and reclamation. (2 600 words & fig.)

1929 656 .1 (.73)
Railway Age, N° 17, October 26, section two, p. 1000.
Short lines find motor coaches useful. (2 300 words & fig.)

1929 656 .261 (.73)
Railway Age, N° 17, October 26, section two, p. 1003.
JEROME (F. C.). — How the New York Central uses motor trucks. (1 700 words & fig.)

1929 656 .261 (.73)
Railway Age, N° 17, October 26, section two, p. 1009.
HANNAUER (G.). — Joining the railways and high-ways. (2 200 words & fig.)

## Railway Engineer. (London.)

1929 625 .232 (.42)
Railway Engineer, November, p. 413.
New rolling-stock for the « Cornish Riviera » Express, Great Western Railway. (1 700 words & fig.)

1929 625 .143
Railway Engineer, November, p. 423.
Manganese and the rail wear problem. (2 300 words.)

1929 621 .13 (.54) & 621 .335 (.54)
Railway Engineer, November, p. 425.
Steam and electric locomotives, Great Indian Peninsula Railway. (4 000 words & fig.)

1929 656 .255
Railway Engineer, November, p. 434.
Improved methods in the operation of single tracks. — VII. (2 600 words & fig.)

1929 625 .142 .3 (.42)
Railway Engineer, November, p. 437.
A steel sleeper improvement. (300 words & fig.)

1929 621 .9 (.42)
Railway Engineer, November, p. 438.
A new boring, facing and radiusing machine. (650 words & fig.)

1929 625 .144 .4 (.42)
Railway Engineer, November, p. 441.
Rail laying with small ramps. (1 000 words.)

1929 621 .133 .7 (.42)
Railway Engineer, November, p. 443.
Improved type feed water heating apparatus, London & North Eastern Railway. (1 200 words & fig.)

1929 625 .144 .2
Railway Engineer, November, p. 445.
HEARN (G.). — The re-alignment of railway curves. — III. (1 700 words & fig.)

1929 621 .133
Railway Engineer, November, p. 447.
Some new developments of the Stephenson boiler. (1 500 words.)

## Railway Engineering & Maintenance. (Chicago.)

1929 624 .7 (.73)
Railway Engineering and Maintenance, October, p. 412.
How to avoid poor concrete. (2 800 words & fig.) .

1929 725 .33 (.73)
Railway Engineering and Maintenance, October, p. 416.
One man replaces three at water station. (2 400 words & fig.)

1929 725 .31 (
Railway Engineering and Maintenance, October, p.
Rock Island remodels old buildings and installs modern facilities at a marked saving compared with cost of a new structure. (2 200 words & fig.)

1929 625 .143 .3 (
Railway Engineering and Maintenance, October, p.
Seams in base blamed for fracture of rail. (1 words & fig.)

1929 625 .1 (06 (08 (
Railway Engineering and Maintenance, October, p.
Roadmasters' Association meets at Chicago. (32 words & fig.)

## Railway Gazette. (London.)

1929 625
Railway Gazette, N° 14, October 4, p. 501.
All-steel railway coaches. (4 500 words & fig.)

1929 621
Railway Gazette, N° 14, October 4, p. 507.
Some new developments of the Stephenson bo (1 500 words.)

1929 656
Railway Gazette, N° 14, October 4, p. 514.
The operation of single lines of railway. — X (1 700 words.)

1929 385. (07 (
Railway Gazette, N° 15, October 11, p. 537.
Railway signalling school, Ceylon Government Railways. (4 500 words & fig.)

1929 656
Railway Gazette, N° 15, October 11, p. 546.
The operation of single lines of railway. — (1 600 words.)

1929 621 .133 .3 (
Railway Gazette, N° 15, October 11, p. 551.
Cleaning locomotive boiler tubes. (400 words & fi

1929 656
Railway Gazette, N° 16, October 18, p. 577.
The operation of single lines of railway. — XV. ( words & fig.)

1929 625 .232
Railway Gazette, N° 16, October 18, p. 583.
New sleeping cars for the International Sleeping Company. (1 800 words & fig.)

1929 621 .33 (
Railway Gazette, N° 16, October 18, p. 587.
Electric traction on British railways. (1 000 wo

**1929** 656 .23 (.42)

Railway Gazette, Nº 18, November 1, p. 657.

GIBB (R.) and ROSE (J. C. D.). — **A bird's-eye view of the goods traffic on an English railway.** (1 300 words & 3 tables.)

**1929** 656 .253 (.54)

Railway Gazette, Nº 18, November 1, p. 661.

COX (H. E.). — **Resignalling** of Victoria terminus, Bombay, Great Indian Peninsula. (4 000 words & fig.)

**1929** 621 .138 .2 (.41)

Railway Gazette, Nº 18, November 1, p. 668.

**Mechanical coaling plant** for the Great Southern Railways, Ireland. (750 words & fig.)

**1929** 621 .132 .8 (.68)

Railway Gazette, Nº 18, November 1, p. 671.

**New Beyer & Garrat locomotives** for the Rhodesia Railways. (1 700 words & fig.)

**1929** 656 .255

Railway Gazette, Nº 18, November 1, p. 675.

**The operation of single lines of railway.** — XVII. (1 800 words.)

**1929** 621 .33 (.54)

Railway Gazette, Nº 19, November 8, p. 701.

**Main line electrification,** Great Indian Peninsula Railway. (4 400 words & fig.)

**1929** 621 .132 .5 (.944)

Railway Gazette, Nº 19, November 8, p. 711.

**3-cylinder 4-8-2 freight engines** for the New South Wales Government Railways. (800 words & fig.)

**1929** 625 .1 & 656 .2

Railway Gazette, Nº 19, November 8, p. 714.

**Railway engineering and transport.** Presidential address of Mr. W. W. Grierson, C. B. E., to the Institution of Civil Engineers, November 5, 1929. (2 700 words.)

**1929** 656. 255

Railway Gazette, Nº 19, November 8, p. 716.

**The operation of single lines of railway.** — XVIII. (2 000 words.)

## Railway Mechanical Engineer. (New York.)

**1929** 621 .335 (.71) & 621 .43 (.71)

Railway Mechanical Engineer, October, p. 574.

Canadian National's 2 660-Hp. **oil electric locomotive.** (3 200 words & fig.)

**1929** 625 .235. (06 (08 (.73)

Railway Mechanical Engineer, October, p. 578.

**Equipment painters** discuss problems at Kansas City (14 000 words & fig.)

**1929** 625 .2 (06 (08 (.73)

Railway Mechanical Engineer, October, p. 591.

**Interest increases in work of general foremen.** (9 000 words & fig.)

**1929** 621 .9 (06 (08 (.73)

Railway Mechanical Engineer, October, p. 599.

**Tool foremen hold constructive convention.** (6 000 words & fig.)

**1929** 625 .24 (06 (08 (.73)

Railway Mechanical Engineer, October, p. 607.

**Car officer's meeting at Chicago.** (14 000 words & fig.)

**1929** 621 .132 .3 (.73)

Railway Mechanical Engineer, October, p. 621.

**Ten 4-8-4 type locomotive** for the Denver and Rio Grande Western. (1 000 words & fig.)

## Railway Signaling. (Chicago.)

**1929** 656 .25 (06 (08 (.73)

Railway Signaling, October, p. 355.

**Signal section meets in Atlanta, Ga.** (14 000 words & fig.)

**1929** 656 .254 (.73) & 656 .255 (.73)

Railway Signaling, October, p. 370.

ZANC (W. F.). — **Burlington replaces mechanical plant with remote control.** (2 900 words & fig.)

**1929** 656 .254 (.73)

Railway Signaling, October, p. 375.

FOX (E. N.). — **Boston & Maine installs either direction signaling in Hoosac tunnel.** (9 000 words & fig.)

## University of Illinois Bulletin. (Urbana.)

**1929** 624. (02

University of Illinois Bulletin, Nº 49, August 6, p. 1.

SEELY (F. B.) & JAMES (R. V.). — **The plaster-model method of determining stresses applied to curved beams.** (4 300 words, 4 tables & fig.)

### In Spanish.

## Gaceta de los Caminos de hierro. (Madrid.)

**1929** 385 .1 (.43)

Gaceta de los Caminos de hierro, Nº 3597, 20 de Septiembre, p. 313.

**Situación financiera de los Ferrocarriles del Reich en 1928.** (1 600 palabras.)

## Ingenieria y Construcción. (Madrid.)

**1929** 62. (01 & 691

Ingenieria y Construcción, Octubre, p. 511.

BOLOMEY (J.). — **Determinación de la resistencia probable de un hormigón conociendo su dosificación y su densidad en el momento del amasado.** (2 800 palabras & fig.)

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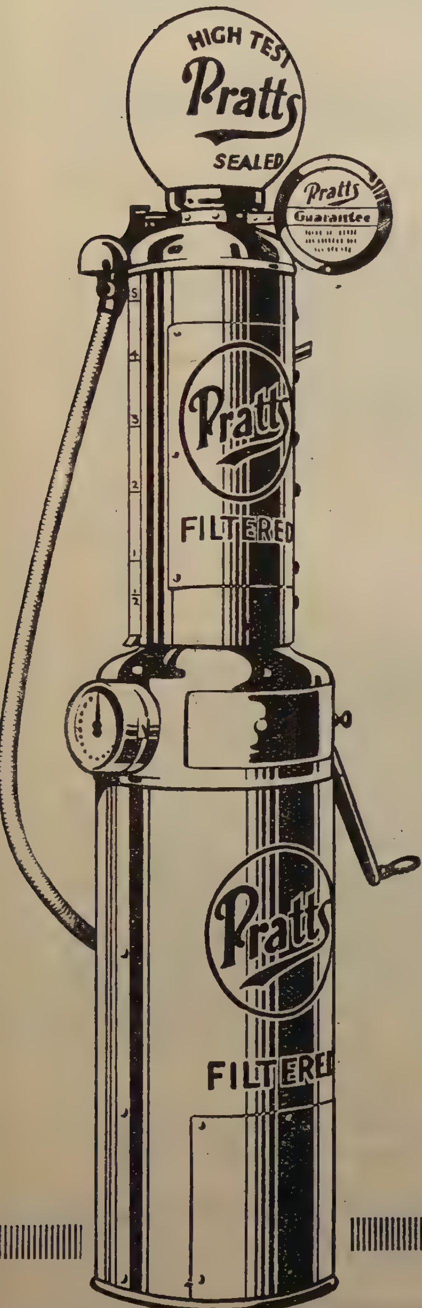


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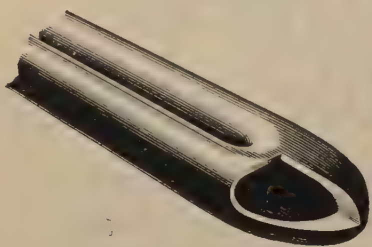

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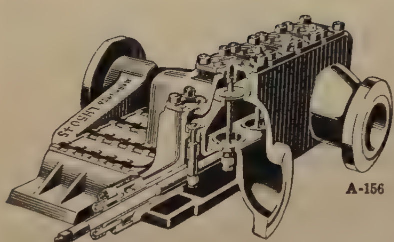

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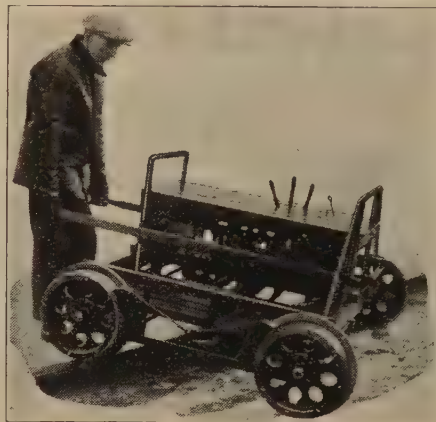

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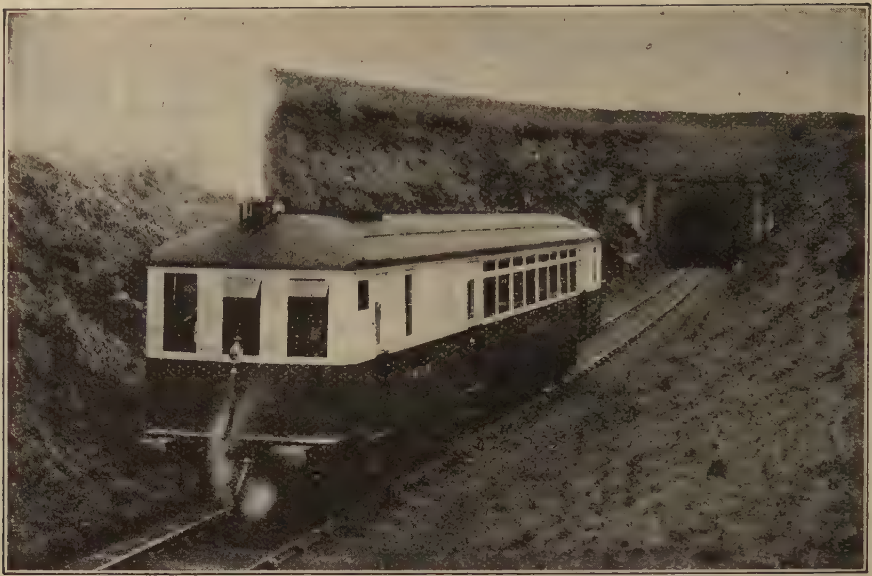

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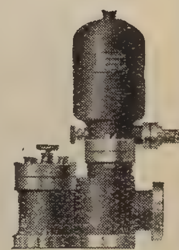

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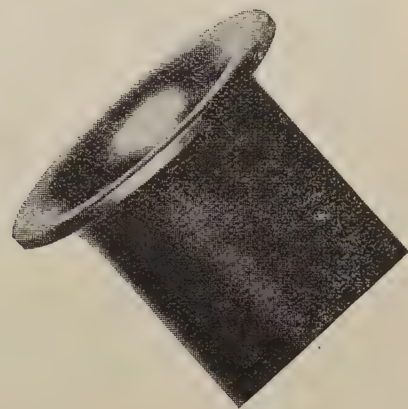

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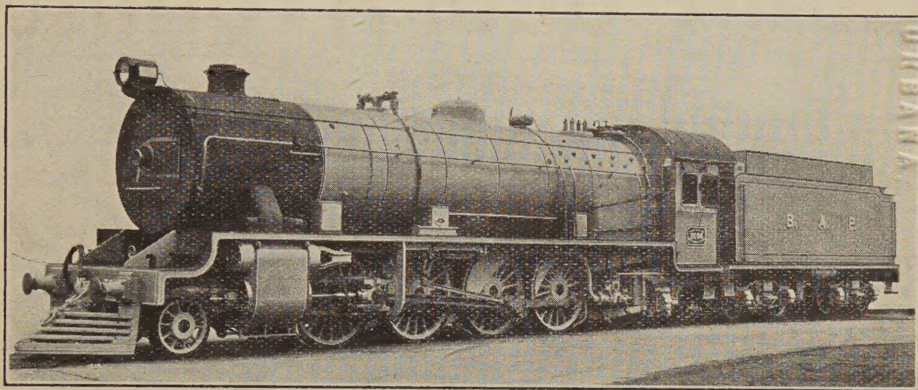

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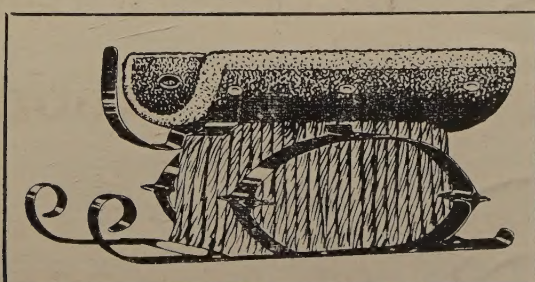

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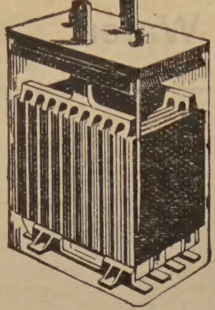

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